User manual

Green ECO Therm

for installation and exploitation
of wood gasification hot water boiler of series :

PYROTHERM

http:// www.greenecotherm.eu

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Thank You for buying the wood gasification boiler of series “Pyrotherm”. This manual will help You to use and maintain the unit properly.

The user manual applies to the following types of hot water boilers: **“Pyrotherm 25”, “Pyrotherm 32”, “Pyrotherm 42”** and **“Pyrotherm 52”.**

This document is intended to be used as additional information for the service team, which will install and adjust the boiler, as well as maintenance information, which will help the end user.

The producer requires the service staff, which will perform the above mentioned procedures, to get training course at the producer’s training center and get certified as well.

ATTENTION! *In interest of your personal security it is obligatory to read thoroughly and carefully this instruction manual before proceeding with any actions with the system – mounting, connecting, etc. its elements. In case that requirements, depicted in this manual are not satisfied, failures of any element of the system could be expected, or even fatal consequences, for which the boiler’s producer does not take responsibility;*

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1. Main properties and advantages of the wood gasification hot water boiler of series "Pyrotherm"

1.1. Basic information for the hot water boiler

The wood gasification hot water boiler of series "Pyrotherm" is steel-plate hot water boiler, which uses solid biomass fuel in shape of wood logs. The boiler is designed to be connected to local hot-water heating systems, as well as heating up domestic hot water. The boiler uses wood logs with moisture content up to 20% (the parameters of the fuel are described below), the resulting heat energy from thermo-chemical conversion (i.e. combustion process) is transmitted to the circulation water in its water jacket and the heat energy is transported to the heating system/consumer. The design of the boiler is optimized in order to achieve high efficiency and low cost heating process, as well as easy maintenance, ash removal and servicing. The hot water boiler of series "Pyrotherm" is manually fuel fed boiler. The combustion process is organized in the combustion chamber of the boiler.

The set of the hot water wood gasification boiler of series "Pyrotherm" consists of the following :

- *Hot water boiler of series "Pyrotherm"* - 1 sp;
- *Combustion chamber ceramic directing element* - 1 sp;
- *Thermovalve for control of air flow rate* – 1 sp;
- *Steel ash cleaning brush* – 1 sp;
- *Ash scrapper* – 1 sp;
- *User manual for installation and exploitation of hot water boiler of series "Pyrotherm"* – 1 sp*;*

1.2. Basic information for the **pyrolisis** process.

The pyrolisis process is chemical decomposition of the biomass through heating of the matter. The word pyrolisis is coined of two Greek words „*pyro*" – fire and „*lysis*" – decomposition. The wood pyrolisis process is realized at certain conditions, the products of this process are volatile gases, which are utilized like gas combustion process. The pyrolisis gases are extracted out of the fuel chamber and are directed through a ceramic nozzle and oxidized in the combustion chamber, reaching high intensity of the combustion process and high efficiency. This process have many advantages – the combustion process could be optimized and allows efficient utilization of the fuel material. The design of the how water boiler of series "Pyrotherm" allows optimal conditions for the above mentioned process, so they are

named “pyrolisis” hot water boilers**.** The fuel ignition, as well as the fuel charging is done manually, the ash deposition cleaning is also done periodically by hand – this allows achieving optimal combustion process and efficient and low cost heat energy for the heating system.

The boiler could utilized the following fuel – wood logs, preferably chopped wood logs, having the following properties:

- Pure wood, contaminated (i.e. painted, chemically treated as well as other mineral or organic substances) wood is not allowed;
- The length of the wood logs should correspond with the depth of the fuel chamber of the boiler – *see the specification of boiler*;
- The cross section (the diameter) of the wood logs should be : $D \leq 200mm$;
- The moisture content of the raw material should be less than 20% ($W^r \leq 20\%$);
- It is possible along with the wood logs to utilize other wood based fuel – like saw dust, shavings and other small fuel particles, but their quantity should be less than 20% of the total charged fuel in the chamber of the boiler;

The boiler consists of

- Steel plate heat exchanger, which transfers the heat energy from the flue gases to the heating media (in most cases this is circulating water);
- Flue gas fan, which extracts the exhausted gases out of the boiler;
- Fuel chamber;
- Ignition flap, utilized at the initial phase of fuel ignition and boiler heating up;
- Ceramic insulated combustion chamber;
- Convective duct, which also heats up the air, consumed for the combustion process;
- Dash board for control and monitoring of the operating parameters of the boiler;
- Thermal insulation – made of mineral wool;

The boiler is equipped with

- Thermo-manometer, which indicates both the operating temperature and the operating overpressure of the circulating water;
- Operating thermostat, which controls the flue gas fan;

- Thermostat, which indicates the thermal condition of the boiler and indicates if the boiler needs to be cleaned of the accumulated ash - **option**;
- Alarm thermostat, which switches off the power supply of the boiler in alarm overheating mode of the boiler;
- Emergency cooling coil, utilized in case of alarm overheating of the boiler;

Advantages of the boiler

- The boiler is designed to utilize wood biomass, which makes it ecologically clean and environmentally friendly and its operation does not contribute to the global warming of the Earth;
- The price of the thermal energy, derived by utilizing the boiler like local energy source is less influenced by the world prices of the other fuels and energy sources, which makes it attractive and competitive, compared with the common known energy sources;
- The manual feeding of the fuel in the boiler allows easy control of its thermal capacity, which guaranties high thermal comfort and fuel savings;
- High efficiency;
- Low pollutants;
- Opportunity to heat up domestic hot water (DHW);
- Simplified maintenance and service;
- Minimal running costs;

2. Technical data of wood gasification hot water boiler of series "Pyrotherm"

- Thermal and technical data for the wood gasification hot water boiler of series "Pyrotherm" are given in **Table 2.1**;
- Dimensions and technical data for the wood gasification hot water boiler of series "Pyrotherm" are given in **Table 2.2;**
- Parameters of the recommended fuel are given in **Table 2.3**;
- Low heating value of wood logs is given in **Table 2.4**;

Parameter	**Dimension**	**Value**			
Model		**25**	**32**	**42**	**52**
Nominal thermal capacity	*kW*	*25*	*32*	*42*	*52*
Thermal capacity operation range	*kW*	*13 - 25*	*16 - 32*	*21 – 42*	*26 - 52*
Utilized fuel	*Wood logs for heating purposes, water content up to 20%*				
Wood logs consumption rate at nominal thermal capacity	*kg/h*	*7.9*	*10.2*	*13.3*	*16.5*
Fresh air flow rate, required for effective combustion process and boiler operation	*kg/h*	*93*	*120*	*157*	*195*
	m^3/h	*81*	*104*	*136*	*169*
Flue gases mass flow rate	*g/s*	*28.1*	*36.1*	*47.3*	*58.6*
Averaged wood logs consumption rate (the boiler is operating in a popular heating system)	*kg/h*	*5.5*	*7.0*	*9.3*	*11.5*
Thermal efficiency at nominal capacity	*%*	*85*			
Flue gasses temperature at nominal thermal capacity	*°C*	*180 – 250*			
Solid fuel residue	*ash*	*The quantity depends on the ash contents in the raw fuel, as well as operating conditions*			

Table 2.1. Thermal and technical data for the wood gasification hot water boiler of series "Pyrotherm";

Parameter		Dimension	Value			
Model			**25**	**32**	**42**	**52**
Weight		*330*	*330*	*330*	*370*	*450*
water jacket capacity		*60*	*59*	*59*	*78*	*89*
Fuel chamber capacity		*100*	*100*	*100*	*130*	*170*
		16 - 20	*16 - 20*	*16 - 20*	*20 - 24*	*25 - 30*
Interval of time for nominal thermal capacity after fuel chamber charging		*hours*	*2 - 3*			
Maximal wood log length		*mm*	*330*	*330*	*500*	*700*
Overall dimension of the system: (WxDxH)	**W** - *width*	*mm*	*780*			
	D - *depth*		*975*	*975*	*1123*	*1321*
	H - *height*		*1282*			
Operating overpressure of the circulating water		*MPa*	*0.2*			
Hydraulic losses of the circulating water at nominal thermal capacity		*hPa*	*3.54*	*5.27*	*14.23*	*8.37*
Heating system expansion vessel type		-	*opened or closed*			
Factory tested overpressure		*MPa*	*0.4*			
Recommended circulating water temperature in the boiler		*°C*	*80 - 85*			
Minimal recommended return water temperature in the boiler		*°C*	*60*			
Draught		*hPa*	*0.18 - 0.24*			
Connections	*Supply/return flow*	*G*	*1½”*			*2”*
	Drainage	*G*	*3/4”*			
	Emergency cooling coil	*G*	*½”*			
	Flue gases duct	*mm*	*150*			
Power supply		-	*L1, N, PE, 50Hz; 230V;*			
Power supply cable		-	*3 x 1.5mm²*			
Electrical capacity		*VA*	*32*	*32*	*65*	*65*
Electric protection		-	*IP20*			
Class of the boiler (according to EN 303-5)		-	*3*			

Table 2.2. Dimensions and technical data for the wood gasification hot water boiler of series “Pyrotherm”;

Parameter	Dimension	Value
Fuel type	*Wood logs*	
Length of the wood logs	*mm*	*See Table 2.2.*
Moisture content	*%*	*≤ 20%*
Low calorific value of the fuel (LHV)	*MJ/kg*	*>13.9*
	kWh/kg	*>3.9*

Table 2.3. Proximate parameters of the recommended fuel – *predried and chopped wood logs*;

EXPLANATION: *one of the most important parameters of the fuel is its calorific value (its heat content). The calorific value (also known as heating value) is function of the moisture content of the wood logs (the moisture is mechanically conserved water in the fuel. The biomass is a natural product and the moisture content of a raw material could be 40 to 60% (the just cut down material can contain up to 80%).*

In order to achieve economic operation of the boiler and to achieve efficient combustion process, it is necessary to supply fuel with minimal water content, for pyrolisis types of boilers it is recommended the moisture content to be up to 20%, which is practically realized by natural drying of the material (at ambient conditions) for a relatively long period of time (at least for a year), during the summer period the drying is high intensified. The fuel should be protected from accident moistening (from example by rain or snow). In order to achieve uniform and intensive during it is highly recommended to chop the wood logs into smaller pieces. However, it the wood logs are stored for a longer period (more than two years), its calorific value is also decreased due to devolatilization of the biomass;

The so called Low Calorific Value of the fuel (LHV) – the heat energy, achieved at combustion, but the latent heat of the water vapor in the flue gases is not retrieved could be calculated from the following equation:

$$LHV = \frac{HHV * (100 - W^r) - 2.44 W^r}{100}$$ *, [MJ/kg], where :*

LHV *– Low Heating Value of the fuel, [MJ/kg];*
HHV *= 18.0 [MJ/kg] – High Heating Value of the fuel (this is the energy of the fuel, which includes the latent heat of evaporation of the water vapor in the flue gases, i.e. the water has been condensed);*

The dependency of the Low Heating Value as function of the moisture content W^r is given on the following figure:

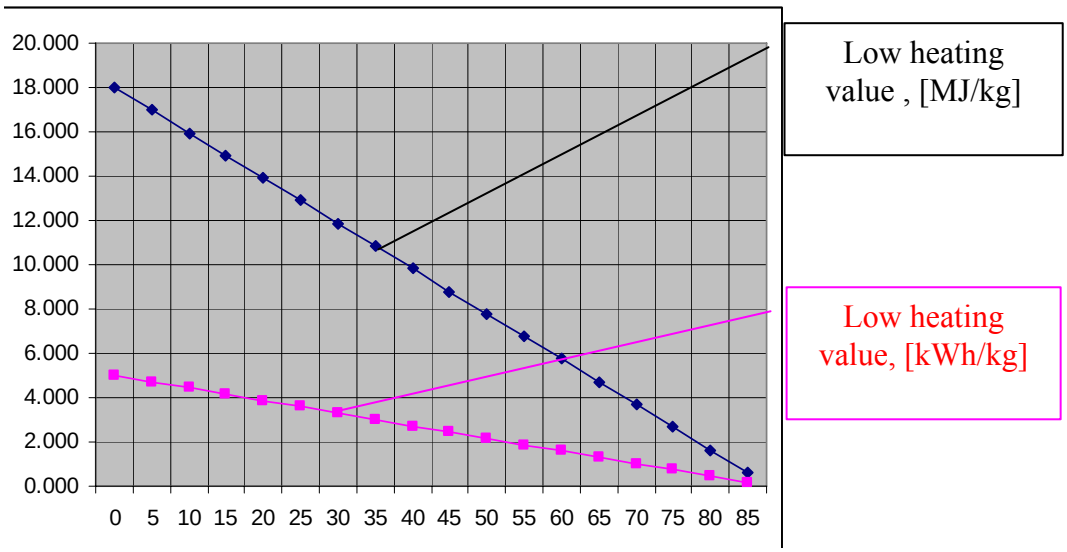


Figure 2.1. Low heating value of wood log (*abscise* – moisture content $\mathbf{W^r}$, [%], *ordinate* – low heating value **LHV**);

Moisture content	**Low heating value**	
$\mathbf{W^r}$	**LHV**	
[%]	[MJ/kg]	[kWh/kg]
0	18.000	5.000
5	16.978	4.716
10	15.956	4.432
15	14.934	4.148
20	13.912	3.864
25	12.890	3.581
30	11.868	3.297
35	10.846	3.013
40	9.824	2.729
45	8.802	2.445
50	7.780	2.161
55	6.758	1.877
60	5.736	1.593
65	4.714	1.309
70	3.692	1.026
75	2.670	0.742
80	1.648	0.458
85	0.626	0.174

Table 2.4. Low Heating Value of wood logs as function of moisture content $\mathbf{W^r}$ of the raw fuel **% (w.b.)**;

3. Description of the wood gasification hot water boiler of series “Pyrotherm”.

The heat exchanger of the hot water boiler of series “Pyrotherm” complies with the acting requirements for such kind of units, defined in operating norm : *EN 303-5/2000 – „Heating boilers for solid fuels, hand and automatically fired, nominal heat output up to 300 kW. Terminology, requirements, testing and marking”.*

The hot water boiler consists of the following elements/modules:

- **Heat exchanger** is steel plate welded construction. In the upper section of the boiler is the fuel hopper, which is manually fed with wood logs. This fuel chamber makes optimal conditions for fuel pyrolisis process and the volatile gases are directed to the lower section of the boiler, where they are oxidized in the combustion chamber. In the combustion chamber is positioned ceramic lining – a nozzle and a flue gas directing element, which allow efficient combustion process;
- **Combustion nozzle**, produced from ceramic material, placed in the lower section of the fuel hopper, which ensures optimal conditions for efficient combustion process;
- **Ceramic directing element**, which is positioned in the combustion chamber of the boiler, allowing high temperature levels and ensures optimal fuel oxidation;
- **Flue gases fan** is installed in the back side of the boiler – it transports the exhausted flue gases out of the boiler and controls the operation of the boiler;
- **Air distribution box**, which has primary air control valve. This box also serves as heat exchanger and preheats the ambient air before being consumed in the combustion chamber of the boiler. The inlet of this box has inflow control flap, which is driven by thermovalve and controls the total mass flow rate of the air, sucked in the boiler;
- **Inflow orifice** has internal thread (for the size see table 2.2) and is positioned on the back left lower side of the heat exchanger, **the outflow orifice** has internal thread as well (for the size see table 2.2) and is positioned in the back left upper side of the boiler. Use this orifices in order to connect the boiler to the heating system;
- **Drainage orifice** has internal thread (for the size see table 2.2), which should be connected to a drainage valve;

- **Emergency cooling coil** is utilized for alarm cooling of circulating water in the boiler's heat exchanger in case that the water temperature has reached high levels. This coil has connecting thread of size G½";
- **The flue exit duct** (the external diameter is described in table 2.2) is positioned in the back upper of the boiler and extracts the flue gases out of the convective section of the boiler;
- The heat exchanger is thermally insulated with **mineral wool**, which allows lower heat loses to the surrounding atmosphere;
- **The doors** of the fuel hopper and the combustion chamber are fabricated from cast iron, which allow high thermal resistance and air tightness of the boiler;
- **The outer covers** of the boiler are manufactured from steel plates and are finally color painted;

The next figures show the dimensions and the design of the wood gasification hot water boiler of series "Pyrotherm".

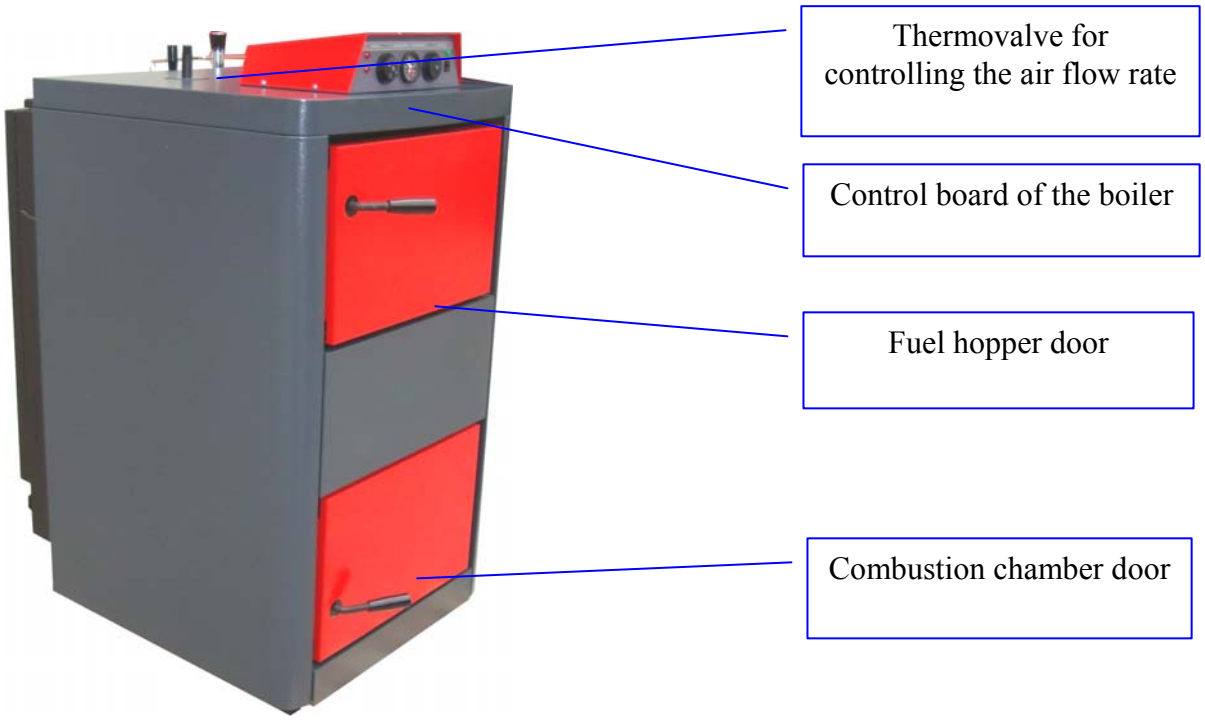


Figure 3.1 Side view of wood gasification hot water boiler of series "Pyrotherm" – *the main elements of the boiler are described*;

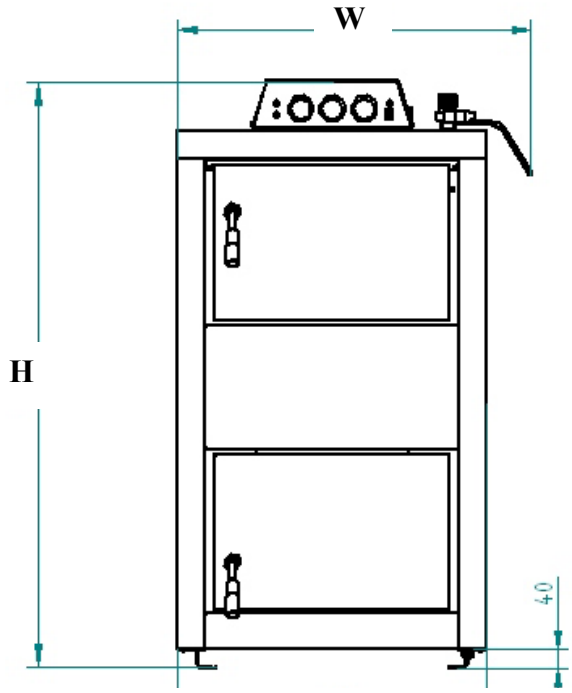


Figure 3.2. View of the wood gasification hot water boiler of series "Pyrotherm" – *front view*;

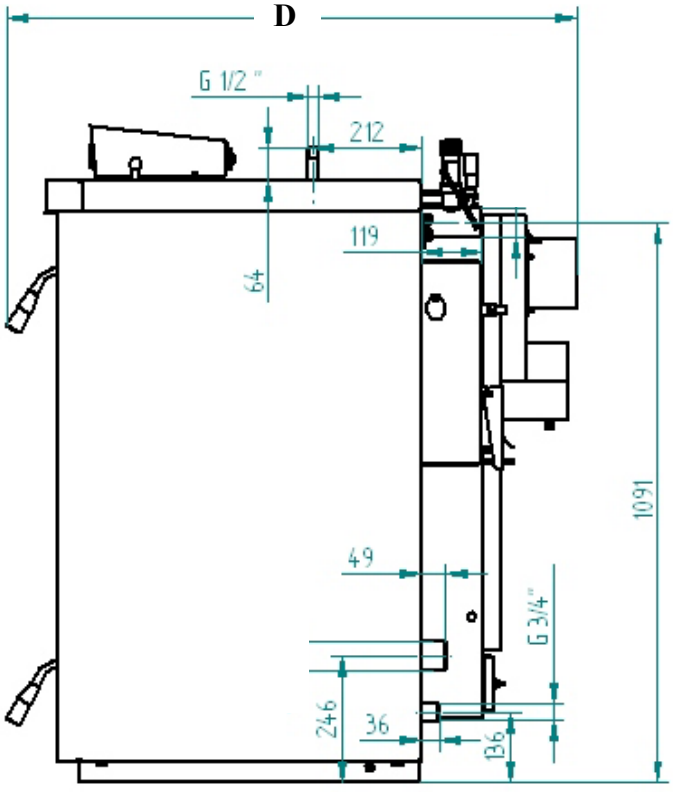


Figure 3.3. View of the wood gasification hot water boiler of series "Pyrotherm" – *side view*;

EXPLANATION : *the value of the dimensions, marked with :***W, H** и **D** *are given in table 2.2*;

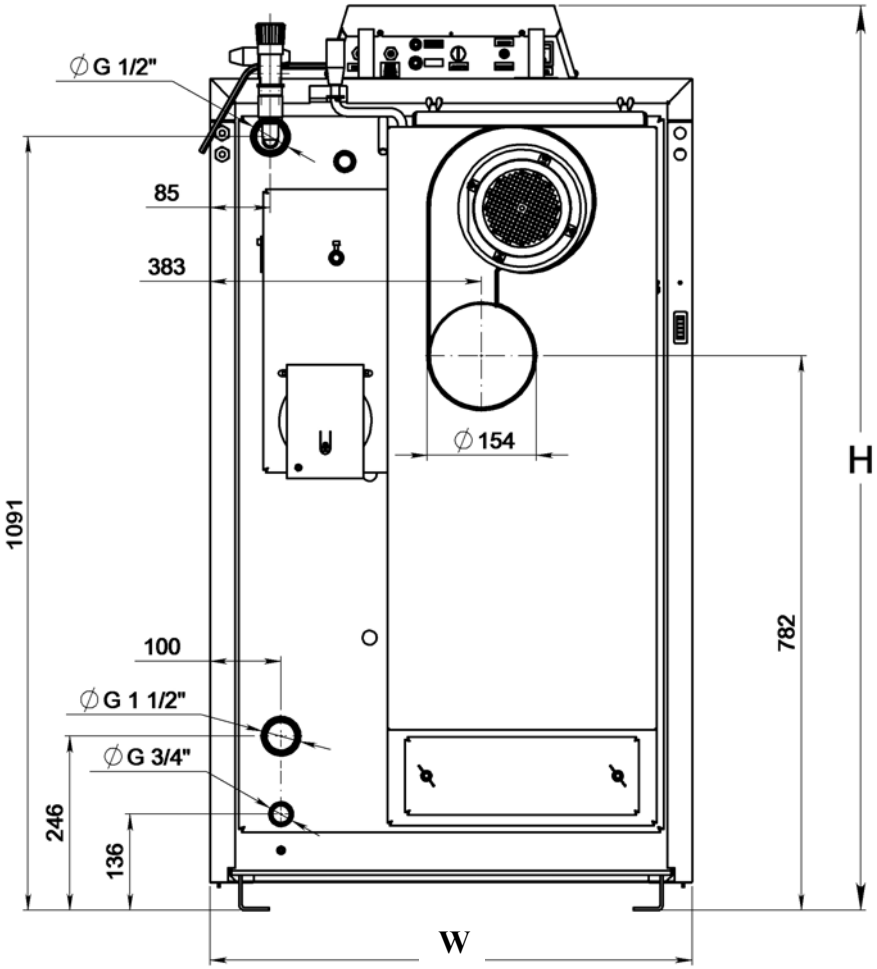


Figure 3.4. View of the wood gasification hot water boiler of series "Pyrotherm" – *back side view*;

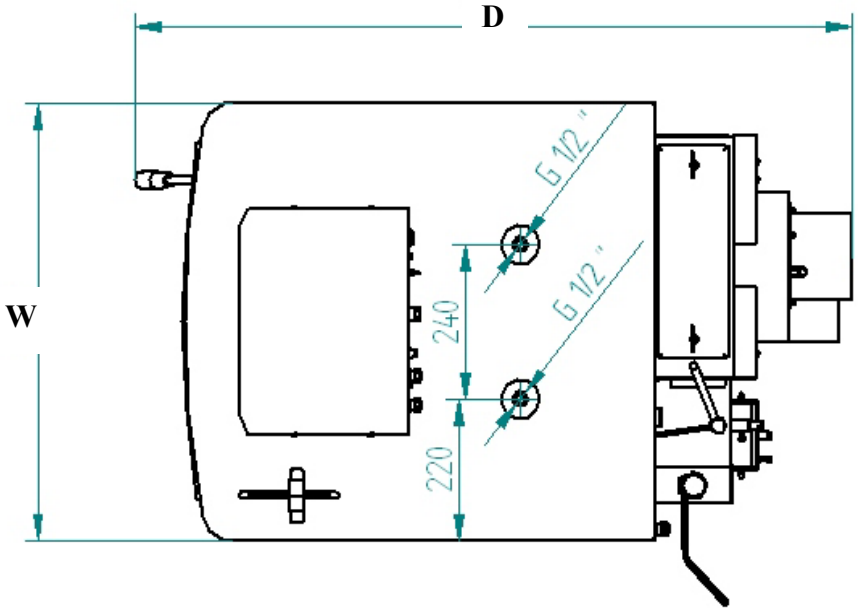


Figure 3.5. View of the wood gasification hot water boiler of series "Pyrotherm" – *top view*;

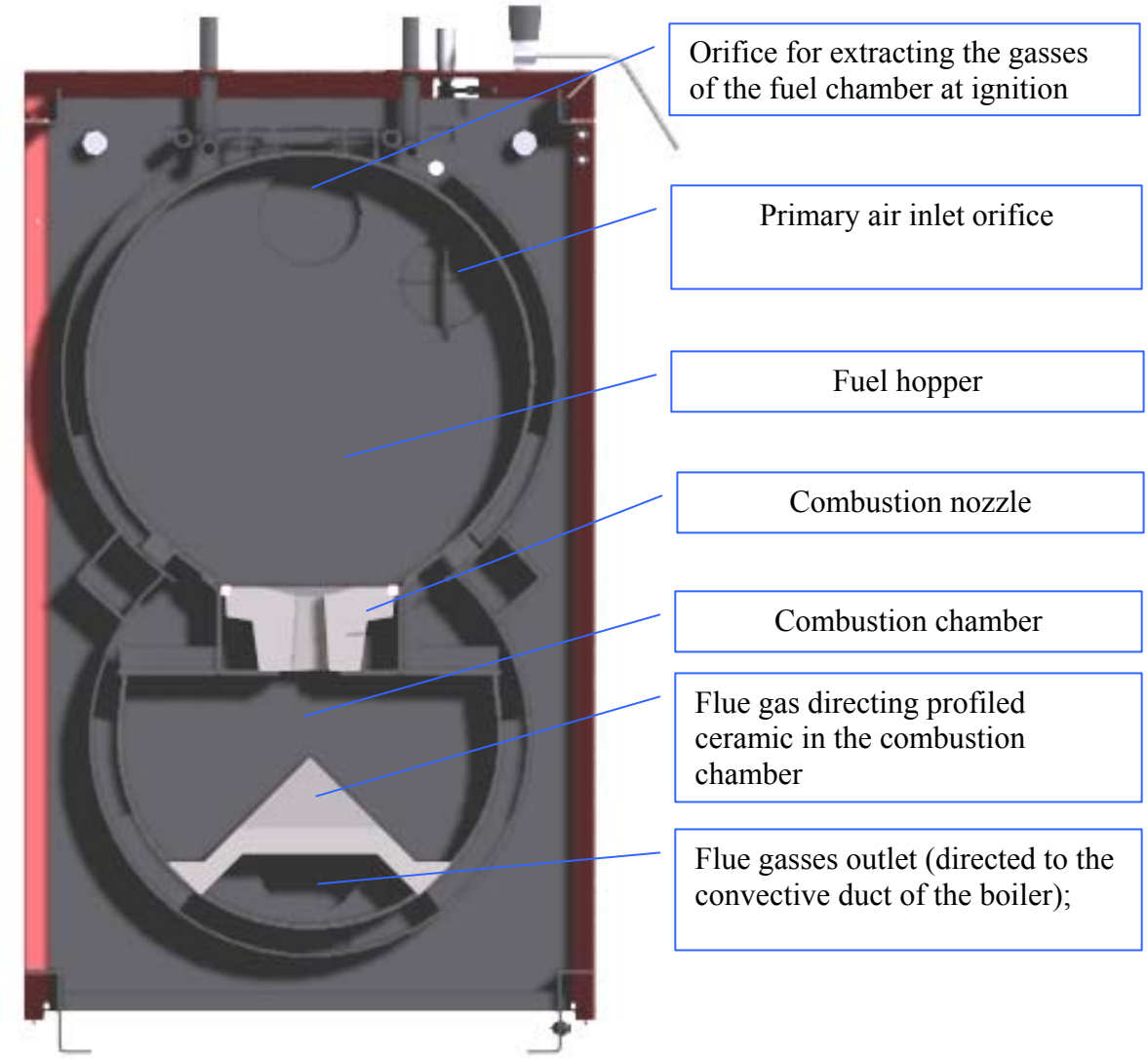

Orifice for extracting the gasses of the fuel chamber at ignition
Primary air inlet orifice
Fuel hopper
Combustion nozzle
Combustion chamber
Flue gas directing profiled ceramic in the combustion chamber
Flue gasses outlet (directed to the convective duct of the boiler);

Figure 3.6 Cross section view of wood gasification how water boiler of series "Pyrotherm";

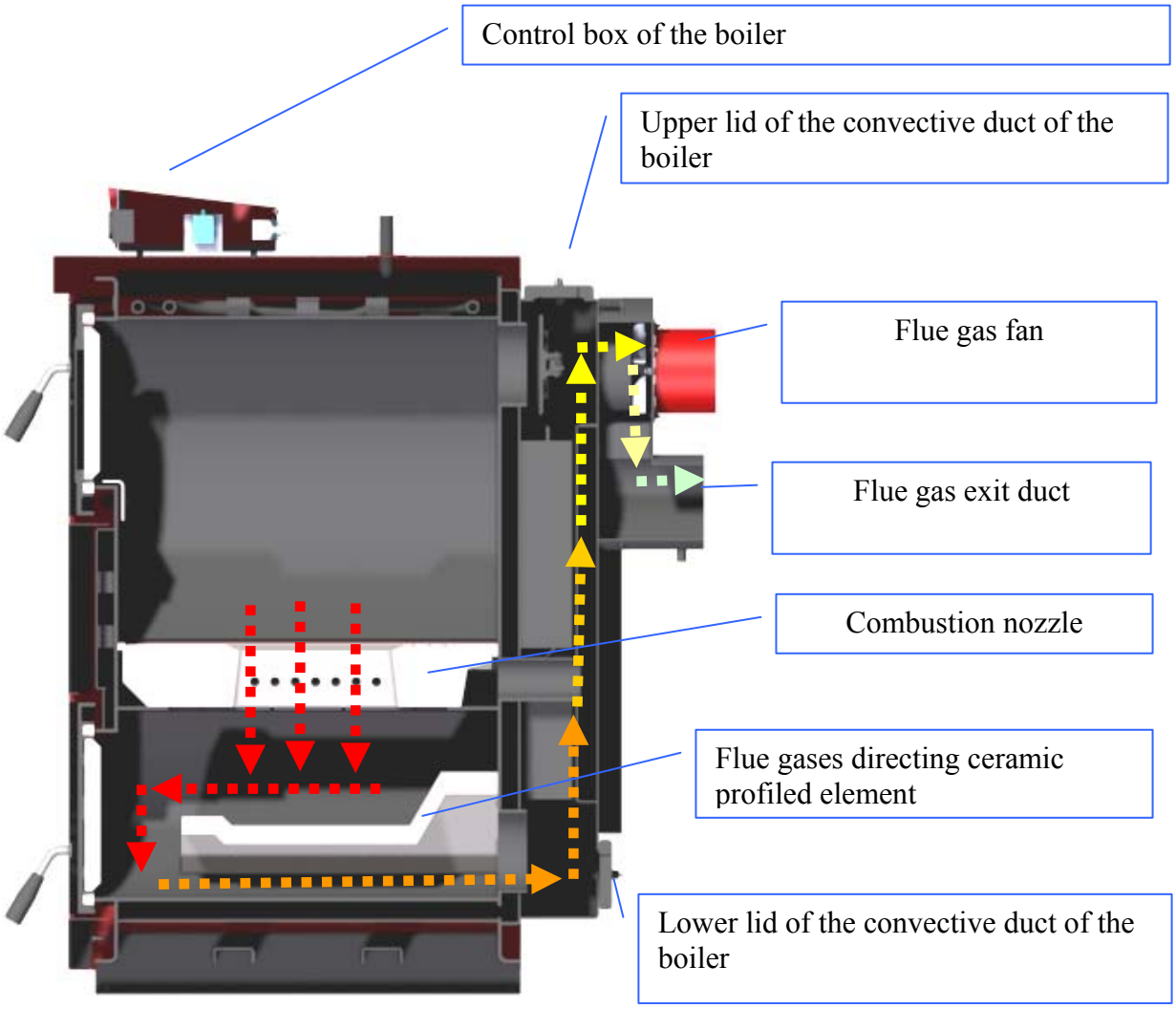

Control box of the boiler
Upper lid of the convective duct of the boiler
Flue gas fan
Flue gas exit duct
Combustion nozzle
Flue gases directing ceramic profiled element
Lower lid of the convective duct of the boiler

Figure 3.7. Longitudinal section of wood gasification hot water boiler of series "Pyrotherm";

The producer reserves the right to make any changes of the design and construction of the boiler without obligation to inform the end user.

4. Installation of the hot water boiler of series "Pyrotherm"

Norms and requirements.

4.1. Basic requirements for installation of wood gasification hot water boiler of series "Pyrotherm":

- The room, dedicated to mount the hot water boiler should be supplied with fresh air supply duct, necessary for optimal combustion process as well as room ventilation;
- Installation of the hot water boiler in inhabitable premises, including dwelling corridors, is not allowed;
- The hot water boiler should be connected to the heating system by authorized personal only;
- Installation and service procedures of the hot water boiler should be performed by authorized qualified and certified personal ONLY;
- The wood gasification boiler of series "Pyrotherm" could be attached to a heating system, equipped with **opened** or **closed** expansion vessel, which should be designed for the water capacity of the entire heating system (its capacity is calcutated at the step of heating system project development);
- Both the entire heating system and the hot water boiler should be totally filled with circulating fluid (water) and air-free before operating the boiler;
- Maintenance procedures of the boiler (as well as the heating system) should be performed by trained adult persons, which have read the user manual of the unit;

ATTENTION: at the transport of the boiler, take care to preserve the ceramic element, mounted in the combustion chamber of the boiler not to be cracked or damaged (secure the detail, or even transport it separately from the boiler);

Installation procedure of the hot water boiler requires engineering project for the heating system, prepared according to the acting local norms and recommendations as follows:

- To the heating system - EN 303-5/2000 - „*Heating boilers. Part 5 : Heating boilers for solid fuels, hand and automatically fired, nominal heat output of up to 300 kW. Terminology, requirements, testing and marking*";

- To the chimney;
- Fire prevention requirements;
- To the power circuit - EN 60335-1/1997- "*Household and similar electrical appliances – safety, Part 1 – General requirements*";
- The ambient air inflow orifice of the boiler's room should have cross section of minimum 0.04 m^2;

4.2. Basic requirements for installation of wood gasification hot water boiler of series "Pyrotherm", considering it's easy maintenance and servicing:

- The boiler should be installed on thermally safe and noncombustible pad, which should have height of 50 mm;
- The minimal space in front of the boiler for cleaning, maintenance etc, should be 1000 mm;
- The minimal distance allowed between the back side of the boiler and a wall should be 400 mm;
- The minimal distance from the boiler's side and a wall should be 500 mm, in order to allow easy maintenance and servicing procedures of the boiler's convective heat exchanger and back side of the unit;
- The minimal distance between the opposite side of the boiler and a wall should be 500 mm in order to ensure easy access to the heat exchanger and to allow easy cleaning of the deposited ash;
- The minimal distance between the top side of the boiler and a wall (ceiling) should be 600 mm, in order to ensure easy access to the control board of the unit, for attachment of the emergency coil, as well as for the cleaning and maintenance procedures of the heat exchanger;

EXPLANATION: after the hot water boiler is positioned, the following procedures of the installation process should be performed:

- The ceramic flue gas directing element should be placed in the combustion chamber of the boiler;

Figure 4.1. Ceramic flue gases directing element, which should be positioned in the combustion chamber of the boiler;

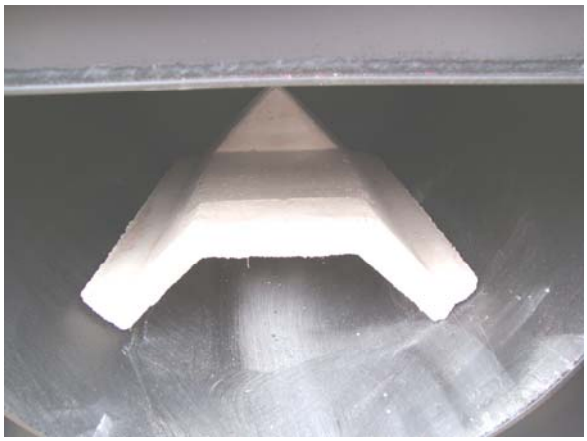


Figure 4.2. Ceramic flue gases directing element is positioned in the combustion chamber of the boiler;

ATTENTION: *at the mounting and installation of the ceramic element should be done with care and preventive measures should be taken in order to keep this element's integrity. After the element has been installed in the combustion chamber, it should be pushed backwards in order to touch the back vertical plate of the heat exchanger*.

- Install the thermovalve, which controls the air flow rate;

Figure 4.3 The thermovalve for controlling the air flow rate for the combustion process is installed and its rod is connected to the air flap (*by the applied chain*);

EXPLANATION: *the adjustment of the chains' length and the opening of the inflow air flap should be performed at operating hot water boiler, reached operating thermal parameters. In order to initially start the boiler, the air flap should be opened and thus to allow air flow in the boiler*;

- Install a self opening valve, which opens at high levels of temperature (not module of the boiler delivery). The valve opens and directs tap water to the emergency cooling coil of the boiler, thus decreasing the circulating water temperature). See the user manual of valve for more details;

  EXPLANATION: *the sensing section of the thermovalve should be screwed in an orifice, positioned in the upper back side of the heat exchanger. The water flow control module of this thermovalve should be mounted on one of the emergency coil ends (no matter which end will be chosen as inflow and the other – as outflow). The water flow control module of this thermovalve should be connected to the tap water, which will be under the pressure of the tap water of the domestic fresh water supply system (or any other source of water at appropriate pressure level). The outflow of the emergency cooling coil should be connected to the drainage systems, in case of emergency hot water should be drained safely*;

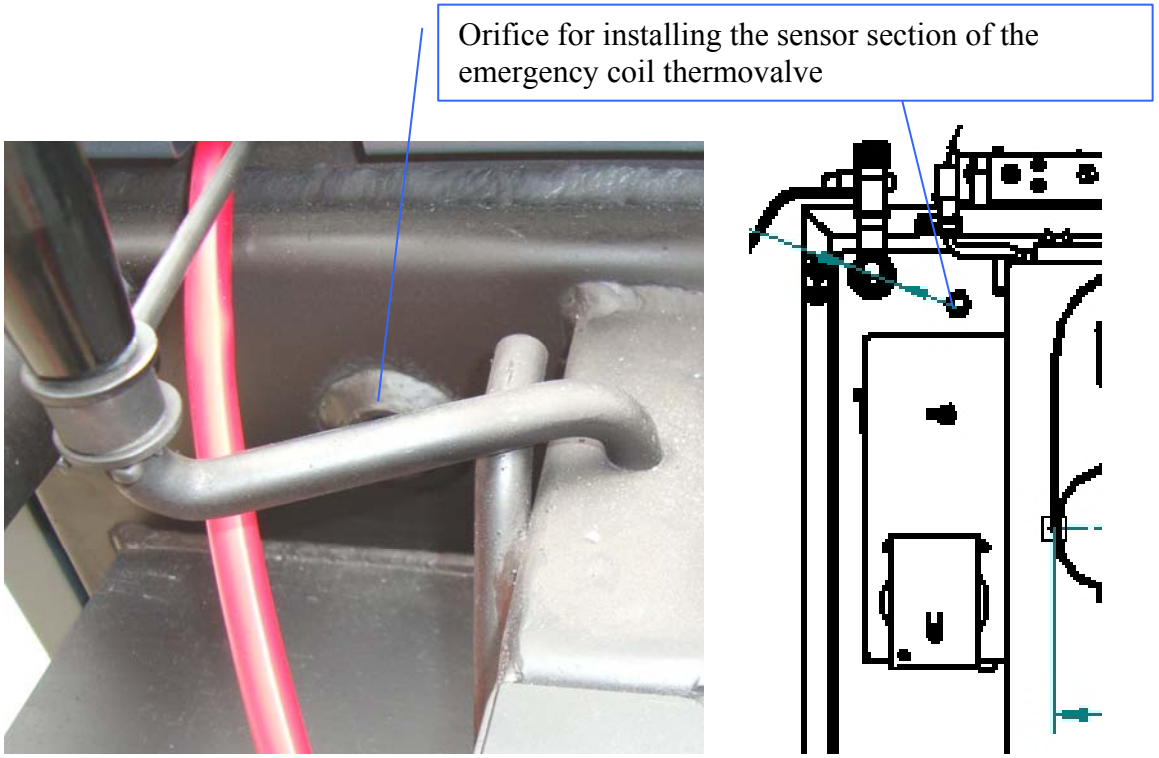


Figure 4.4. View of the orifice of the hot water boiler, where the sensor module of the thermovalve for emergency cooling coil with tap water should be screwed in;

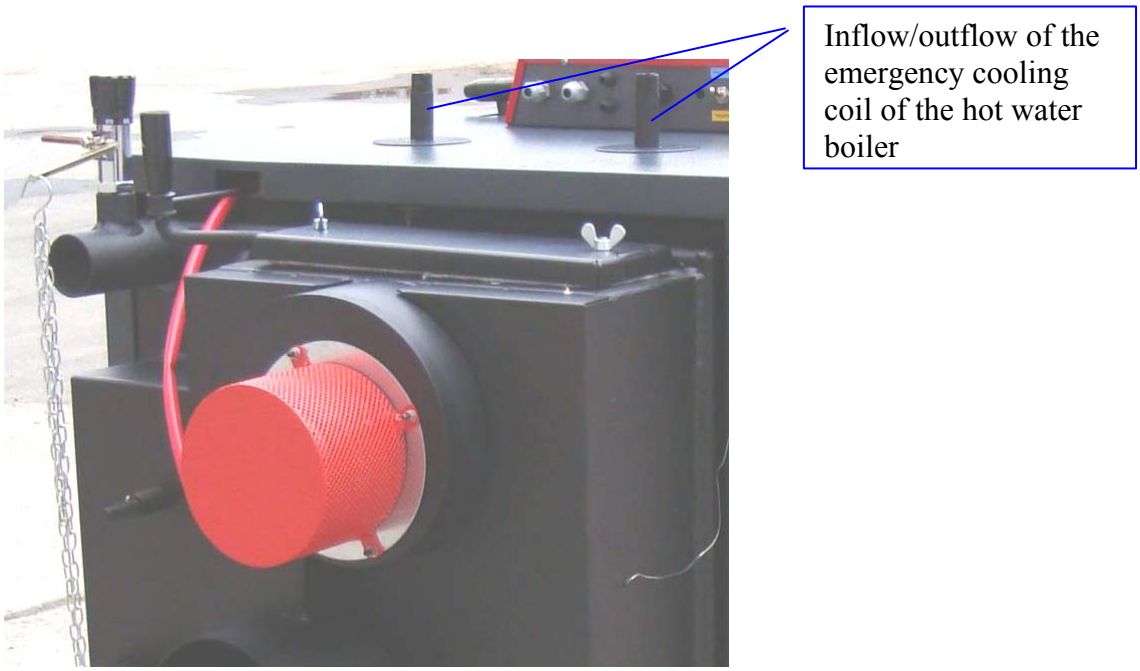


Figure 4.5. View of the back side of the boiler - *the ends of the emergency cooling coil are pointed*;

- Connect the inflow and outflow of the hot water boiler to the heating system – use appropriate fittings, etc, according to the installation project;

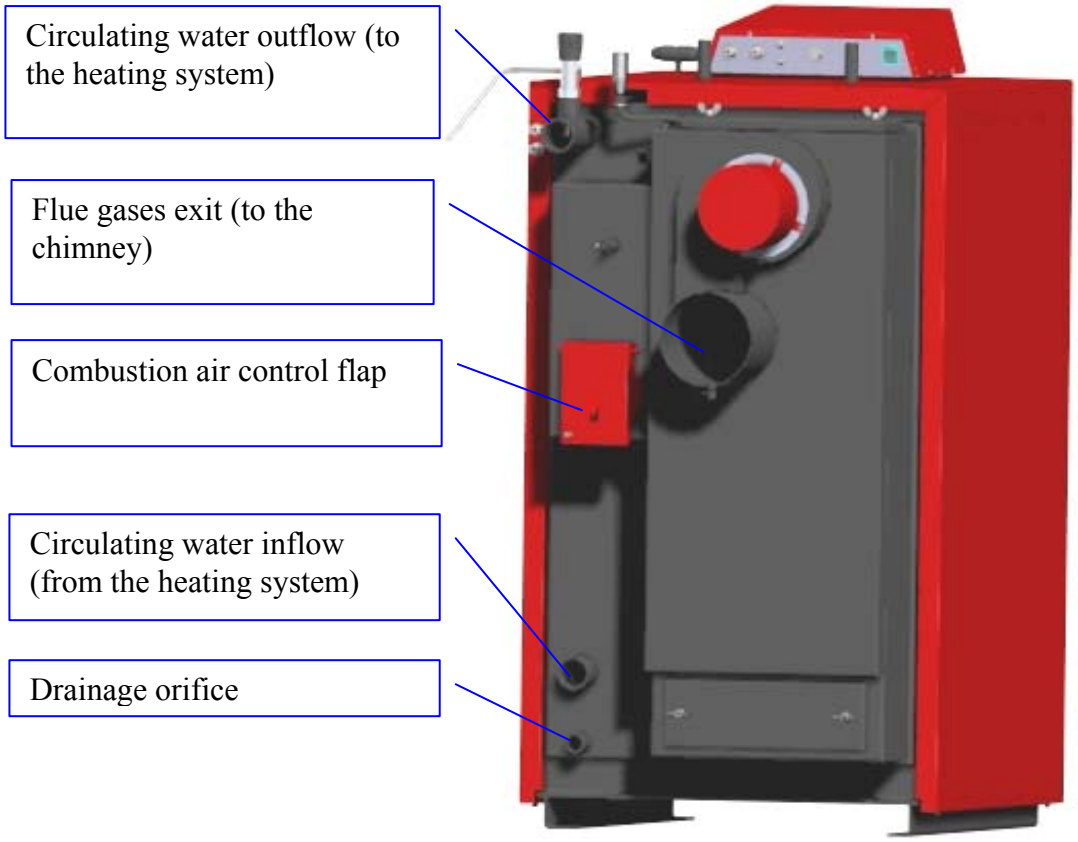

Circulating water outflow (to the heating system)
Flue gases exit (to the chimney)
Combustion air control flap
Circulating water inflow (from the heating system)
Drainage orifice

Figure 4.6 Backside view of the hot water boiler of series "Pyrotherm" - *the connections are pointed*;

- Position the boiler, considering the requirements for attaching the electrical power supply – *position the boiler in order to ensure easy access to the power supply plug box (230V/50Hz)*;

ATTENTION: *the finalization of the boiler's installation and commissioning of the boiler's operation, as well as the heating systems, should be notified in the warranty list – filling all the data fields is obligatory*.

- The heating system and the boiler should be filled up with circulating water – most commonly tap water is utilized. However, the water, used for filling the heating system should be transparent, colorless, no sediments, oil contents or any other aggressive chemical components. The hardness as well as other properties of the water should cover the requirements, described in the table below. In case the water does not cover these requirements, it should not in any case being used, the water should be chemically treated or other water should be used instead.

The water, utilized to fill the heating system, as well as the hot water boiler, should cover the following requirements (according to BDS 15207-81):

Parameter	**Dimension**	**Value**
Total hardness	mg.eq/kg	30
Oxigen content	mg/kg	100
Free sulfide content	mg/kg	2
Oil and other heavy oil derivatives content	mg/kg	3
Total hardness	mg/kg	50
Salt contents	mg/kg	6000
Dispersed matter contents	mg/kg	5
Total alkalescency	mg/kg	30
pH	-	8.0 – 9.5
Free CO_2 contents	mg/kg	not allowed

Table 4.1. Parameters of the water, allowable to be used as circulating fluid in a heating system.

In case the heating system contains copper elements and the circulating water id in direct contact with them, the pH of the circulating water should not exceed 10.

ATTENTION: ***The finalization of the system installation and performing the commissioning tests should be filled in the appropriate documents of the boiler, where the required data fields should be filled in (this is obligatory).***

The boiler's producer recommends *a principal hydraulic scheme for attaching the hot water boiler to the heating system, equipped with three way valve and a heat accumulator, as shown on figure 4.7.*

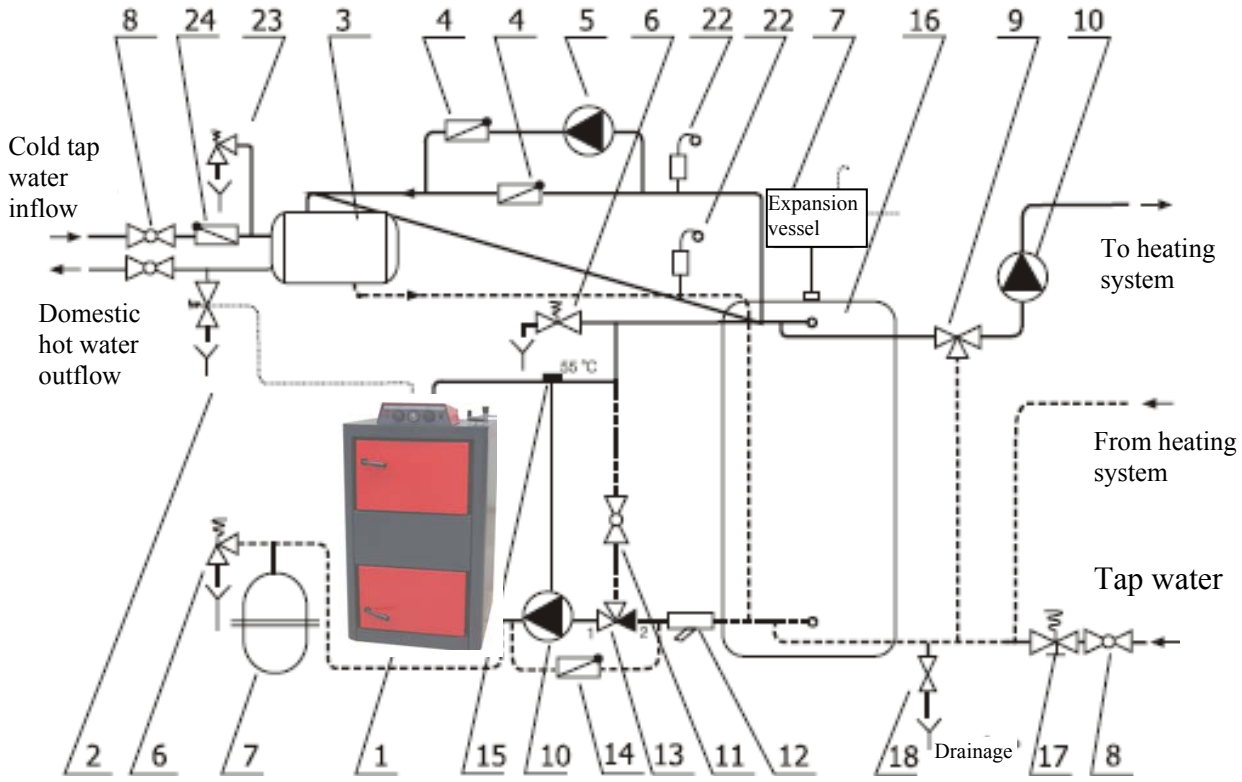


Figure 4.7 Recommended principal hydraulic scheme for connecting the hot water boiler of series "Pyrotherm" to the heating system, equipped with three-way valve and heat accumulator;

Index	Designation
1	Hot water boiler "Pyrotherm"
2	Safety valve
3	Hot water boiler
4	Return valve
5	Circulating pump 1
6	Control valve
7	Expansion vessel
8	Control valve
9	Three way mixing valve
10	Circulating pump 2
11	Control valve

Index	Designation
12	Water filter
13	Thermovalve TV
14	Return valve
15	Contact thermostat
16	Heat accumulator
17	Automatic circulating water charger
18	Drainage valve
22	Automatic air separator
23	Safety valve
24	Return valve

Table 4.2. Designation of the elements, indexed on figure 4.7

EXPLANATION : *According to EN 303-5 the heat accumulator tank is obligatory module of a local heating system, operating with solid fuel hot water boiler. The heat accumulator capacity calculation is made according to the above mentioned norm, as well as heat accumulator methodology, developed by boiler's producer company.*

5. Wood gasification hot water boiler of series "Pyrotherm" starting procedures

ATTENTION : The boiler should be installed, adjusted and verified ONLY by trained and authorized staff.

5.1. Basic fuel requirements

- The fuel should be only chopped and dried wood logs, described above. The boiler producer recommends that the fuel should be stored in dry and well ventilated rooms. The fuel should be protected from moisturizing and appropriate storage cares should be taken;
- It is strongly forbidden to store the fuel in close region of the boiler, the minimal safety distance between the fuel and the appliance is 500 mm;
- The unit producer recommends an optimal distance between the boiler and the fuel storage site to be at least 1000mm. It is recommended to store the fuel in room, next to that, where the boiler is installed;
- At the installation procedure of the unit, as well as the fuel storage one, fire prevention recommendation should be considered. It is also recommended to install a fire-extinguisher in a safe and easy accessible place;

5.2. Basic requirements for exploitation of the hot water boiler, connected to a heating system

- *In principle heating systems, which are hydraulically* ***opened*** *to the atmosphere allow direct contact between the circulating fluid (in most cases it is water) and the air. During the heating season the water content in the expansion vessel absorbs oxygen from the atmosphere though the free surface. The increased oxygen content in the water threatens the metal of the unit, as well the pipes. Through the free surface of the expansion vessel water evaporation is observed as well. Considering these, appropriate water should be added through the expansion vessel – it must cover the requirements of norm BDS 15207-81. During the heating season regular checking of circulating water level in the expansion vessel should be performed by the end user. The water content in the circulating system should be kept constant. If additional water is required, then precautions should be taken, not to add air in the heating system as well. Practical experience shows that water level checkup should be performed regularly in a period of 14 days in order to sustain quasi-constant water content. In case that additional water is required, the filling process should be performed carefully, when the hot water*

boiler is cooled to the ambient temperature. This precautions are induced due to prevent rising of thermal stress of the steel boiler's body and its damage (leakage);

- *The water, utilized for filling purposes of the heating system should be decontaminated and air-free, and is not dedicated for any other purposes, but as a circulating fluid only. Any heating system drainage is inadmissible, except when repairing modules/sections of the system;*

- *In case that the heating system is equipped with* ***closed*** *expansion vessel, then it should be known, that these systems are under pressure and practically do not allow direct contact between the circulating fluid and the ambient air. These systems are not threatened by oxygen absorption. However, these systems are pressurized and their pressure should be monitored and controlled if necessary, in order to ensure safe system operation – both the pressure rising could be dangerous, as the mechanical loads of some of the heating system elements gets higher, as well as the lower pressure levels could lead to air penetration, even air suction through small invisible cracks in thermally loaded elements, which will lead to intensive corrosion. That's why during the heating period, it is necessary to check the circulating water pressure periodically and drain or fill if needed. Please pay attention and do not allow air penetration in the heating systems at fill-up process. The circulating water should be utilized only for heating purposes. It is not recommended to drain the circulating water out of the system, except in case of repair works. It is recommended to check and control the water pressure at systems heating up process, as well as on a 14 days period. If water fill-up is needed, then the fluid should cover the requirements, described above;*

- *It is not allowed in any cases to fill the operating boiler with cold water, as this could lead to thermal stresses and could eventually damage the unit. Fill the boiler with additional water only when it is cooled down to ambient temperature;*
- *In case that the boiler as well as the heating installation will not be in exploitation for a long period, then in order to prevent local water freezing and damages, it is advisable to perform total drainage of the circulating water. Please take into account that the presence of liquid in the heating system, as well in the boiler will prevent oxidation process of the metal surfaces, corrosion and system failures;*

5.3. Starting wood gasification hot water boiler of series "Pyrotherm" procedure.

Basic requirements:

- Any maintenance procedures should be performed in accordance with the described in this manual;
- The hot water boiler of series "Pyrotherm should be charged with fuel by person, who has read this user manual thoroughly. ***ATTNETION :*** *the presence of children around the operating boiler is won allowed;*
- Any intervention in the working process of the hot water boiler, which could lead to unit's failure and/or dangerous and health threatening situations, are strongly prohibited;
- In case that the boiler's room can be gasified with easy flammable vapors (for example from organic paints, varnishing, etc.) **the boiler should not be in operation**, as this environment is strongly dangerous and could lead to lethal ambient conditions;
- The boiler should be checked by the maintenance staff or any trained personal regularly;
- The end-user should not perform any interventions, repairs, etc. of the unit. In case that warning and failures arise, check the failures table (applied at the end of this manual) and call the service support if the case is not described there;
- Any intervention and/or changes of the electrical scheme of the boiler is strictly forbidden;
- Any usage of fuel, which is not approved is strongly forbidden, as this could lead to uncontrollable combustion process and flue gasses emmisions, as well as direct boiler's structure threatening;
- Any adjustments/increasing of thermal capacity higher than the nominal thermal load of the boiler are not allowed;
- The positioning of any flammable materials in near vicinity or on top of the boiler is strongly forbidden – place the material, considering the safety perimeter;
- The ash, deposited in the combustion chamber of the boiler, should be collected in fireproof containers and cooled down to ambient temperature. The cooled ash should be disposed in appropriate waste containers. During ash cleaning the presence of combustible materials in region of 1500mm around the boiler are not allowed. Please take into account that the mineral

ash, result of wood logs combustion could be considered as soil fertilizer and dispersed for agricultural purposes for example;

- After the end of each heating season, the boiler, as well as the chimney and the other systems modules should be thoroughly cleaned from the deposited ash, tars, etc, if necessary service maintenance should be performed as well;
- The duration of the boiler's operation depends on the operating mode of the unit, as well the properties of the wood, being chosen as fuel. The practice shows that wood of type : ***beech, oak, ash (fraxinus), sycamore, fruit-trees*** are materials, which allow relatively high duration of the boiler's operation and thus longer period between two fuel charging of the boiler's hopper, because their specific heating value (the calorific value, considered on the fuel volume) ir relatively higher, compared to the other types of wood fuel. The next (considering the calorific value) wood materials, which have lower specific calorific value of the fuel are : ***chestnut-tree, birch, pine spruce*** – they are considered as second grade of quality, considering their calorific values and combustion characteristics. The materials of : ***lime-tree, poplar, willow, elm-tree*** has lowest quality, considered as fuel, because of their lowest specific volume heating value. Also the contents of resin and tat in the wood material will lead to lower quality fuel, as these contents lead to high degree of combustion chamber contamination and lower heat exchanging rates. It should be considered, that the raw wood material (which has high moisture content) have low heating value and will lead to high fuel consumption rates and low boiler's efficiency. These operating modes could lead to intensive chemical corrosion of the heat exchanging surfaces as well, mainly due to the deposited tar particles and organic acids formation.;

The wood gasification hot water boiler of series "Pyrotherm" is fuel manually charged boiler. The boiler's thermal capacity strongly depends on the fuel properties, mainly its moisture contents, as well as boiler's operating mode. The practice shows that efficient pyrolisis process in such type of hot water boilers is achieved at temperature levels of the circulating water above 60^{o}C. That's why one of the main requirements for the efficient operation of this type of boilers is to control the thermal capacity of the boiler and the outflow heat consumption in order to sustain such temperature levels of the water in the boiler. In case that the water temperature is below the above mentioned levels, this will lead to low intensity of volatile gases, released from the wood in the fuel hopper, as well as intensive condensation of the tars on the heat exchanging surfaces of the boiler. This process is highly inefficient and decreases the overall lifetime and reliability of the boiler. The condensed tars form organic acids, which act highly corrosive on the heat exchanger surfaces as well (finally the heat exchanger's wall will be thinned and eventually will be cracked and water leakage will be observed). The practice shows that during the nominal operation

of the boiler and not being touched (no fuel charging, no stirring), the fuel will get bridged, i.e. the fuel particles as well as char will be collected around the burner's orifice and eventually will make blockage. This process will lead to high hydraulic resistance of the burner's orifice and will lead to thermal capacity decrease. That's why it is highly recommended to perform regularly manual stirring of the char particles, oxidizing on the upper surface of the ceramic burner's orifice and eventually cleaning away the obstacles in order to ensure high thermal capacity rates, covering the requirements for personal safety and fire preventive measures. The fuel stirring also decreases the hydraulic resistance of the burner's orifice and thus the thermal capacity of the boiler will be increased, due to high intensity of the volatile gases release of the wood logs in the fuel hopper and efficient combustion process.

5.3.1. Interface control board of wood gasification hot water boiler of series "Pyrotherm"

The front panel of the interface control board of the boiler has the following control devices:

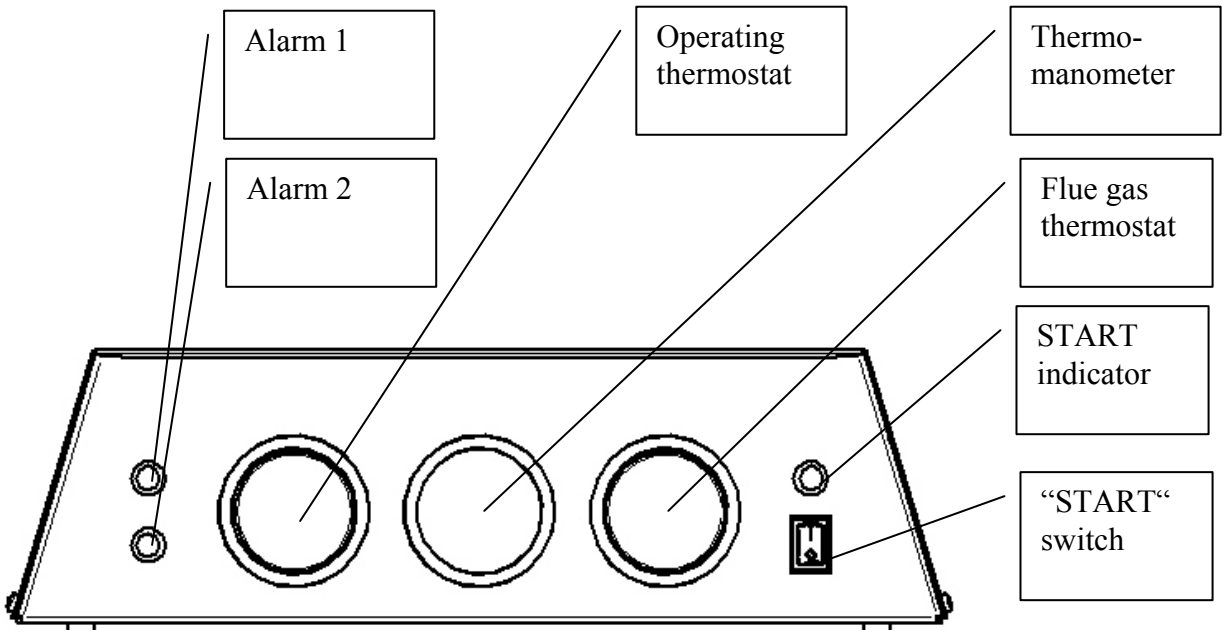


Figure 5.1. Interface control board, equipped with control and operating devices of hot water boiler of series "Pyrotherm" – *front side view*.

- **Operating thermostat** – *assigns the set-point of circulating water in the boiler. The boiler's flue gases fan will run until this set-point is reached and will supply heat energy to the heating system. At stop of the fan the boiler will go into stand-by mode*;
- **Flue gas thermostat** – *assigns the set-point of flue gases temperature. The boiler's flue gas fan will not run at temperature below the set-point of this thermostat and flue gases will not be extracted by the flue gas fan, thus the remaining char will be*

preserved from being consumed, when only char remains in the fuel hopper of the boiler;

- **Thermo-manometer** – *indicates the operating temperature of the circulating water in the heat exchanger jacket of the boiler, well as water overpressure;*
- "**START**" switch – *sends "START/STOP" signal to flue gas fan of the boiler, the boiler wiil operate at nominal thermal capacity (ON) or will go into stand-by mode (OFF);*
- "**START**" indicator – *indicates the status "START/STOP" signal to the flue gas fan of the boiler;*
- **"Alarm 1" indicator – emergency overheating** – *indicates emergency overheating state of the boiler, due to activation of the emergency thermostat. In case of activation, cool down the unit and check and repair the reason for the emergency situation, finally reset the emergency thermostat*;
- ***"Alarm 2" indicator** – **(option)** – indicates the status of the heat exchanger – in case the flue gases temperature is above certain level it will lit and ash cleaning is required*;

The back panel of the interface control board of the boiler has the following control devices:

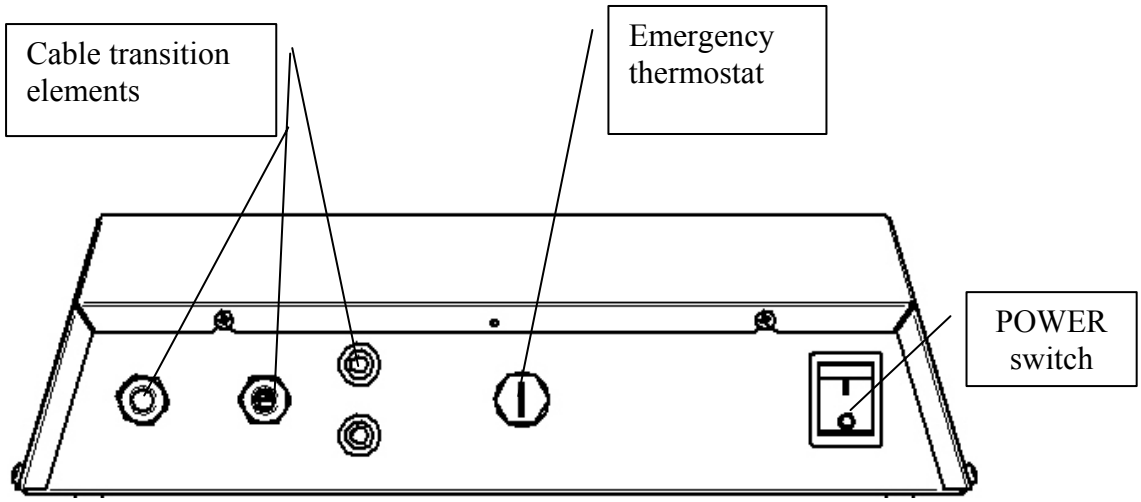


Figure 5.2. Interface control board, equipped with control and operating devices of hot water boiler of series "Pyrotherm" – *back side view*.

- Main "**POWER**" switch – *switches ON and OFF the main power supply of the boiler*;
- **Operation mode switch** – *changes the operation mode of the control module. Keep it in wood gasification (pyrolisis) position;*

- **Emergency thermostat** – *protects the boiler from exceeding emergency temperature level and boiler overheating. This thermostat is factory preset to switch off the power supply of the unit at water temperature in the boiler above 95^{o}C*;

5.3.2. Start-up initialization of the boiler

The hot water boiler of series "Pyrotherm" should be connected to the electrical power supply system, covering the safety requirements;

The hot water boiler of series "Pyrotherm" is switched on by changing the POWER switch into ON position.

Before manual fuel ignition of the fuel in the upper chamber of the boiler, it is necessary to check the functionality of separate elements/modules of the boiler, which sustain its reliability, as well as the heating system efficiency and functionality:

- Flue gas fan;
- Ignition flap;
- Position and condition of the ceramic element in the combustion chamber of the boiler;
- Thermovalve, which controls the air flow rate, as well as its adjustment;
- Functionality of the control and measuring elements (thermostats, thermo-manometer);
- Gasket rope of the doors;
- Circulating pump (in case that such pump is installed in the heating system);

The fuel hopper chamber should be charged with small amount of small kindle particles (for example dry laths, branch-timber, etc) and these particles should form a pile, arranged above the burner's nozzle, lying in lower section of the fuel chamber of the boiler. It is recommended to use no more than 5 kg of this igniters in order to start stable combustion process. The orifice of the burner should not in any case being blocked by the particles, as the volatile gases should pass through the nozzle down to the combustion chamber;

5.3.3. Ignition of the fuel and boiler's heating up

ATTENTION : before ignition of the boiler it is necessary to check the position of the ceramic element in the combustion chamber of the boiler (it should be centered and should touch the back vertical wall of the boiler' combustion chamber).

- The operating thermostat of the boiler should be set to 80^{o}C or any other temperature level of the circulating water in the hot water boiler. ATTENTION : *in order to achieve efficient wood gasification and combustion process, it is necessary to keep the circulating water temperature above 60^{o}C*;
- Turn the set-point of the flue gases thermostat to minimal position;
- Switch off the flue gas fan (turn into off position the START switch). The status of the operating mode of the flue gas fan is indicated with the lamp, mounted above this switch;

The ignition of the fuel, as well as the boiler's heating-up is performed, following the steps, described below:

- Open the ignition flap – the lever for ignition flap control is positioned on the right hand side of the upper section of the boiler, its driven manually by pulling it;

Figure 5.3. The lever for the ignition lever of the boiler is pushed backwards and the flap is **closed**.

- Open the door of the fuel hopper of the boiler, arrange the igniters and make a pile above the orifice of burner, make the pile scarce, so the flue gases could easily pass through the burner's nozzle. Open the door of the fuel hopper, arrange a pile of chopped wood particles (preferable dry pine

wood) above the nozzle. Please pay attention that the pile should not block the nozzle orifice and should allow easy flue gases transition, as well as fresh air. Ignite the initial fuel, preferably use old news papers, but verify that these materials do not emit toxic gases as well as any other harmful gases. ATTENTION – *any flammable liquids usage is not allowed*. The following figure shows arrangement of the igniter fuel particles in the fuel hopper chamber of the boiler;

Figure 5.4. Arrangement of the igniter fuel, required to start the combustion process in the boiler;

- The initial fuel is arranged in the chamber of the boiler, the fuel is ignited up manually (by using a match or a lighter for example) – take care and cover the fire safety requirements. After the initial fuel has been fired up, half-close the door, not allowing any flue gases getting out of this chamber. The flue gases, product of the combustion process are passing through the opened ignition flap and transported by the flue gas fan to the chimney;

  EXPLANATION :

  - *According to the local conditions (the properties of the chimney as well as the atmosphere) the velocity of ignition could vary – it is necessary to make personal observation of this process and achieve practical experience for the firing up process*;
  - *At ignition, as well as at nominal operation of the boiler, it is highly recommended to take care and to prevent any intensive combustion process in the fuel hopper chamber of boiler, because this could lead to excessive temperature levels of the flue*

gases, convected to the chimney and could lead to flue gas fan failures and/or any other elements of the boiler at this duct of the boiler;

- After the initial fuel has been fired-up, the flue gas fan should be switched on (turn the START switch into on position), close the door of the fuel hopper and close the ignition flap , by pushing the lever for driving the ignition flap backwards (see figure 5.3). This will result in change of the direction of the flue gases – they will go through the burner's nozzle and will pass through the combustion chamber and the convective duct section of the boiler, rather then being extracted directly to the chimney, which will lead to intensive heating up of the circulating water in the boiler;
- Turn the flue gases thermostat in order to set it into operating position. This position should be derived experimentally (it is recommended to mark this position for convenience), by observing the ignition process of the boiler;
- Adjust the thermovalve, which controls the air flow rate. At ignition this flap should be opened, in order to guarantee availability of air for the combustion process. After the boiler has been fired-up and the operating parameters have been reached, it is necessary to make appropriate adjustment of this thermovalve functionality (*see the description below*);

  EXPLANATION: *the heated up circulating water, due to the gravitational forces starts to convect, circulating through the boiler's heat exchanger to the heating system (i.e. naturally driven circulation of the heating media), this is observed by increasing the temperature of the inflow and outflow pipes of the system, even if the circulating pump is not functioning (if any is installed). The circulating pump should run, when the operating temperature has been reached, controlled by the operating thermostat (in most of the cases) and the heat energy is transported out of the boiler to the heating system*;

NOTES:

- During the very first start of the operation of he boiler, intensive water vapor condensation on the internal surfaces of the boiler could be observed, even water leakage could be see out of the door of the combustion chamber of the boiler, as well as the flue gases duct flap, positioned on the lower back side of the boiler. This is a single process and will not influence the operation and functionality of the boiler;
- It is not recommended to open the door of the fuel hopper chamber of the boiler, when the flue gas fan is not functioning and ignition flap closed, because volatile gases could be emitted out of this chamber to

the surrounding atmosphere and the boiler's room could be contaminated with gases as well;

5.3.4. Adjustment of the air flow rate control thermovalve

The thermovalve, which controls the air flow rate, required for efficient combustion process, should be adjusted in order to allow optimal operation of the boiler. EXPLANATION : *until the nominal thermal capacity of the boiler is reached, the flap, driven by that thermovalve should be opened, in order to ensure sufficient air flow for the ignition process*.

This thermovalve controls the air flow rate, required for achieving efficient combustion process. This valve closes the air control flap in case the temperature of the circulating water has reached high levels and thus preserves the boiler from overheating. This valve senses the temperature of the circulating water and actuates a lever, which controls the position of the air control flap – at low temperatures of the circulating water this lever opens the air control flap, in reverse, at high temperatures of the circulating water the lever of the valve closes the air control flap and reduces the air flow rate for the combustion process, thus reduces the thermal capacity of the boiler. This thermovalve is functioning without any energy sources – it is proportionally driven and its lever turns linearly by changing the temperature. The position of the air control flap should be observed visually and adjusted manually with the applied chain.

ATTENTION: *the thermovalve should be adjusted in order to get **closed** the air control flap when the temperature of the circulating water has reached 90^{o}C*

Adjustment of the thermovalve should be done in the following way:

- The boiler is heated-up, until the temperature of the circulating water has reached 80^{o}C (measured by the thermo-manometer, installed on the front plate of the control box of the boiler);
- Adjust the position of the handle of the thermovalve – the signature of the thermovalve should be equal with the temperature of the circulating water in the boiler;
- Adjust the applied chain (which connects the lever of the thermovalve with the air control flap) by changing the position of the hook, the position of the air control flap should be opened. The chain should be strained;
- If necessary – adjust the minimal position of the opening of the air control flap – use the adjustment screw. EXPLANATION: *the air control flap should not close tight the air orifice, because this will lead to "suffocation" of the combustion process and intensive tar depositioning*

on the internal surfaces of the boiler. The flap should be opened at distance 3–8 mm, according to the local conditions (chimney's draught, thermal capacity of the boiler, fuel properties, etc);

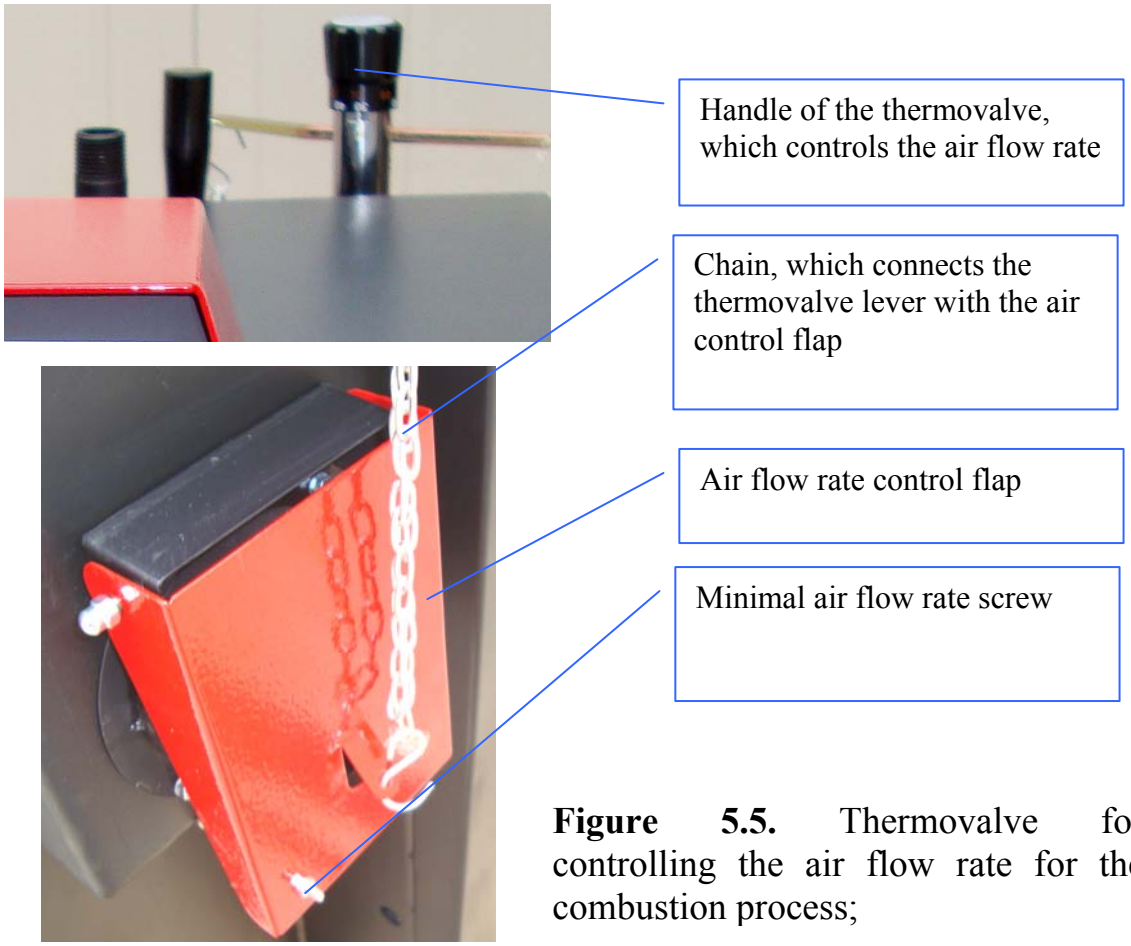

Handle of the thermovalve, which controls the air flow rate
Chain, which connects the thermovalve lever with the air control flap
Air flow rate control flap
Minimal air flow rate screw

Figure 5.5. Thermovalve for controlling the air flow rate for the combustion process;

EXPLANATION : *the methodology of the adjustment of the thermovalve is given in its user manual*;

5.3.5. Nominal operating mode of the boiler

After the process of boiler's starting up (i.e. the fuel has been ignited, the additional fuel has been fired-up, the boiler's temperature has reached high levels, the combustion process is stable and the circulating is circulating in the heating system), the system should be tempered and then the system could be considered in steady-state mode, as well as the hot water boiler. The adjustment of the combustion process should be performed in this nominal operating mode only. The operation of other control valves as well as other control modules should be adjusted in this mode as well. At nominal operating conditions, the circulating water temperature should be in the range of 65 – 85^{o}C. The practice shows that this mode is achieved after 1 to 2 hours after the boiler has been started-up, however the local conditions and the heat consumption should be accounted as well. In this mode the operating parameters the boiler should be

constant (or small deviations could be observed) – the flue gas temperature, the thermal capacity, the flue gas emissions. However, the boiler is manually fuel fed boiler, so small deviations could be observed (according to the frequency of fuel charging rate, as well as the fuel quality and quantity).

EXPLANATION: *the optimal condition of the boiler's operation is achieved at temperature of the circulating water in the range of 65 - 85^{o}C. In this temperature range the boiler operates in optimal thermal condition and the wood gasification process is easy controlled, as well as high efficiency of the combustion process. In case the heating system is equipped with circulating pump, the operation of this pump should follow the above mentioned requirement, i.e. it should operate at temperature of the circulating water above 65^{o}C. In case the boiler operates at temperature levels below this point (65^{o}C), the operation will lead to intensive tar deposition and decreased heat transfer rates, as well as chemical corrosion, which both decreases the efficiency and the reliability of the unit;*

In nominal operation mode the boiler, as well as the heating system should be commissioned (i.e. the so called "hot tests" should be done), considering the requirements and legislations.

NOTES:

- In case that the heating system is equipped with circulating pump, which transfers the heat energy from the boiler to the heating system, the return flow (the cold flow) temperature should not be below 60^{o}C, because there is great chance to achieve local cooling of the flue gases in the boiler, which will lead to intensive vapor condensation and will be followed with chemical corrosion of the heat exchanging surfaces;
- It is not recommended to operate the boiler at thermal capacity below the minimal one, depicted in the operating range of the unit, as such regimes are low efficient and decrease the reliability of the boiler. Such low thermal capacity conditions could lead to conditions, which will result in decomposition and failure of some components of the boiler, also could lead to life threatening conditions as well (mainly carbon monoxide), as well as tar, which will deposit condensation on the internal surfaces of the boiler and corrosion will follow;
- In case the boiler should operate at thermal operating mode, which is below its nominal thermal capacity, it is highly recommended to install a heat accumulator, in order to allow efficient and economic operation of the boiler and flexible operation of the heating system. The heat accumulator tank serves are energy depot, i.e. it accumulates the excessive heat energy during nominal operation of the boiler and the

heating system and releases energy when the boiler does not operate, but there is thermal energy consumption by the heating system. The heat energy, contained in the heat accumulator is utilized both for heating purposes as well as heating domestic hot water (see figure 4.5);

5.3.6. Fuel hopper charging

At nominal operation mode of the boiler, it should be charged with fuel periodically. The fuel charging procedure is described below:

- Open the ignition flap (by pulling the level of the ignition flap – see the figure below), the flue gases in the fuel hopper will be released to the chimney through this flap;

Figure 5.6. Position of the lever, which controls the position of the ignition flap – *the flap is **opened** at the position, shown on the figure above*;

- Wait for 5 - 10 seconds, open the door of the fuel hopper chamber The opening process of the door should be performed in steps – first half-open the door , so the ambient air will penetrate the chamber, do not allow flue gases to be released out of the chamber to the ambient atmosphere;
- Open the door of the fuel hopper chamber and charge with wood logs. It's good idea to have the wood logs arranged, so to make easy the fuel charging process. **ATTENTION :** have preventive measures not to get burned, nor got suffocated with the flue gases, released out of the fuel chamber – wear self-protecting clothes, etc. The fuel should be charged in a manner, that it should be arranged in the chamber, so the volume of the chamber to be optimally filled with wood logs. Place the wood logs in longitudinal manner. Before charging the chamber with new fuel, it is recommended to make stirring of the chars at the orifice of the burner, in

order to allow easy convection of the volatile gases though the nozzle – use appropriate tool, applied with in the maintenance kit of the boiler;

- Close the fuel hopper door, close the ignition flap (push the level);

EXPLANATION : *the fuel charged should be heated-up, that's why at the initial step of fuel charging a decrease of the temperature of the circulating water could be observed. The practice shows, that approximately 30 minutes from the fuel hopper charging process, the thermal capacity of the wood gasification hot water boiler start to rise and soon it reaches its nominal thermal capacity and the boiler gets its nominal operating parameters*;

Figure 5.7. View of the fuel hopper chamber and the status of the fuel after approximately 30 minutes of its charging;

The figure above shows, that the wood logs has already been dried out and even partial carbonization is seen – the wood logs look black, intensive volatile gases release is observed (the smoke), if any combustion process is seen, this is due to fresh air penetration in the chamber, because the door is opened (at nominal operating conditions in this chamber no flame should be seen, only intensive volatiles release).

At fuel hopper chamber charging process, the following procedure should be performed:

- The fuel, that is planned to be charged, should be prepared (it is highly recommended to arrange the fuel at convenient place in near vicinity of the boiler) in order to minimize the time, when the door will be opened

and thus to decrease the chance to release volatile gases out of the chamber and to gasify the boiler's room;

- The fuel should be arranged in the fuel hopper chamber in longitudinal way (along the axis of the burner's orifice), by taking care not to block the orifice of the burner and to allow easy volatile gases extraction to the combustion chamber;
- At wood logs arrangement, take care not to block the door – it should be closed without any difficulty;
- In case the fuel hopper chamber is charged with material of different type, then the particles that have higher moisture content and/or particles with high size, should be arranged in the center of the chamber, while smaller particles, or even better – relatively drier should be arranged at the side zone of the chamber. This approach allows prevention of fuel bridging right above the burner's nozzle and consequently blockage of the nozzle, which could lead do sensible decrease of the thermal capacity of the boiler;

EXPLANATIONS :

- *The practice shows that approximately half an hour from the fuel hopper with wood logs, the nominal operating parameters of the boiler are reached as well as the boiler's thermal capacity. After this period, the boiler will operate at nominal parameters for a long period of time (the range is hours, see the table for the operating parameters of the boiler) – this period greatly depends on the energy consumption and the parameters of the raw fuel;*
- *When the set-point of the temperature of the circulating water is reached, the fuel gas fan will be switched off and the boiler soon will go into "stand-by" mode. In this mode the fuel consumption rate is decreased, as well as the thermal capacity of the boiler. The practice shows that the typical thermal capacity of the boiler in "stand-by" mode is approximately 10% of the nominal thermal load of the boiler. In this mode small amount of air is entering the boiler and sustains the char oxidation in order to keep the boiler in so called "ready-to-operate" mode;;*

5.3.7. Adjustment of the operating parameters of the boiler.

The combustion process should be adjusted at nominal operating conditions, in order to achieve efficient and optimal fuel utilization, It is highly recommended to make the adjustment of the combustion process by flue gas

measurements – use gas analyzer, the adjustment should be performed by trained technician.

The adjustment of the combustion process is performed by regulation of the air flow rate as well as the its distribution. The air, consumed at the combustion process is drawn in to the fuel hopper chamber as well as the burner's nozzle, by the flue gases fan. This air is distributed by an air box , where it is preheated and directed to the fuel hopper chamber (this air is named "primary air") and to the burner's nozzle (this air is named "secondary air"). The air distribution is adjusted by position of a primary air control flap (which is positioned above the orifice for air inflow). The primary air, which is drawn in the fuel hopper chamber is utilized for sustaining the wood gasification (so called pyrolisis) process. The secondary air is utilized for oxidation of the volatile gases, which are passing the burner's nozzle. These gases are mixed with the preheated secondary air, mixed and oxidized in the combustion chamber of the boiler. The above described process allows fuel efficient utilization and low running costs of the heating system. The process could be treated as gas-combustion, because most of the fuel is gasified and combusted in the oxidation chamber of the boiler. The design of the boiler allows optimal conditions for the combustion process and high thermal efficiency, as well as easy control of the thermal capacity and boiler's operating mode. The adjustment of the position of the primary air flow rate control flap requires knowledge of the boiler's operation, combustion process and fuel properties, as well as patience, shown by the technician, in order to achieve optimal results. The practice shows that any variation of the primary air control flap position, influences the operating conditions of the boiler with a delay of approximately 15 to 30 minutes, so in case of position changing, one should wait al least 15 minutes (better wait 30 minutes) in order to get new steady-state operating mode of the boiler and the influence of the flap position to get sensible effect on the combustion process.

The distribution of the air is performed with appropriate adjustment of the primary air control flap, as well as adjustment of the air control flap, driven by the chain, hanged on the lever of the thermovalve (mentioned above). The following figures show details about the air control adjustment. NOTE : there is a manual observation orifice and one could verify the position of the primary air control flap.

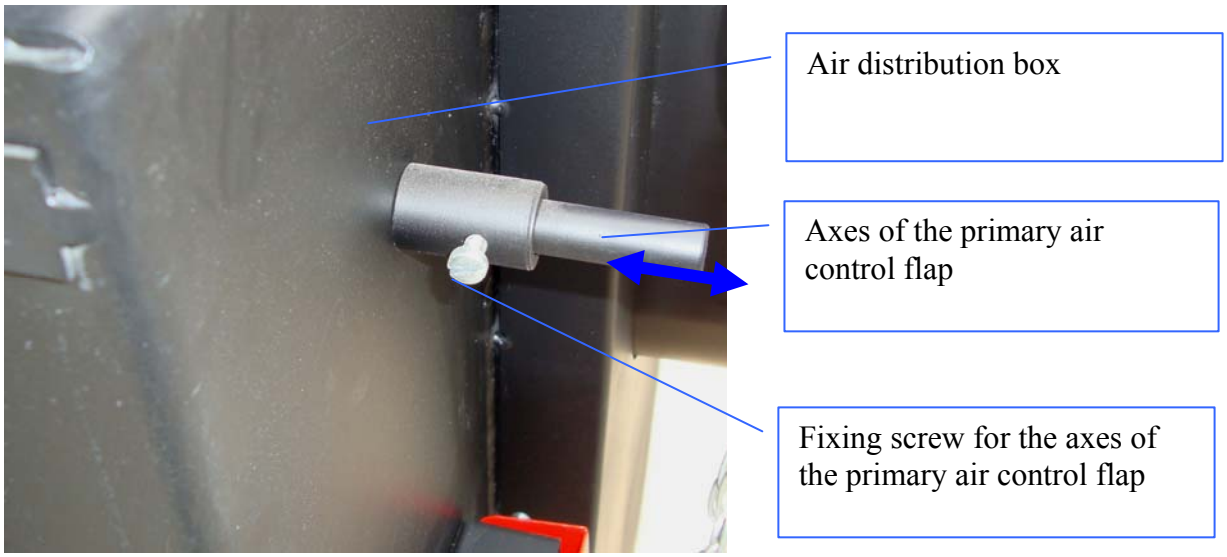


Figure 5.8. View of the axes of the primary air control flap;

The position of the flap could be easily changed by unscrewing the fixing screw, manually push or pull the axes of the flap (i.e. change its position). It is highly recommended to change the position of the flap in small steps – about 1 or 2 mm, and finally fix the primary air control flap with the screw.

EXPLANATION: *small axial movement of the axes of the primary air control flap makes sensible effect on the operating conditions of the combustion process and the overall performance of the boiler. That's why any change of the adjustment of the boiler's air distribution should be followed with appropriate period of time in order get effect. The practice shows, that utilization of wood logs, which cover the requirements, described above, the primary air control flap should be closed (pushed back inside). However, in case the fuel's moisture content is higher than required, then the primary air control flap should be opened to some extend, in order to sustain the pyrolisis process of the fuel in the hopper chamber. Again, change the position of the primary air control flap into small steps, in order to achieve efficient raw fuel devolatilization.*

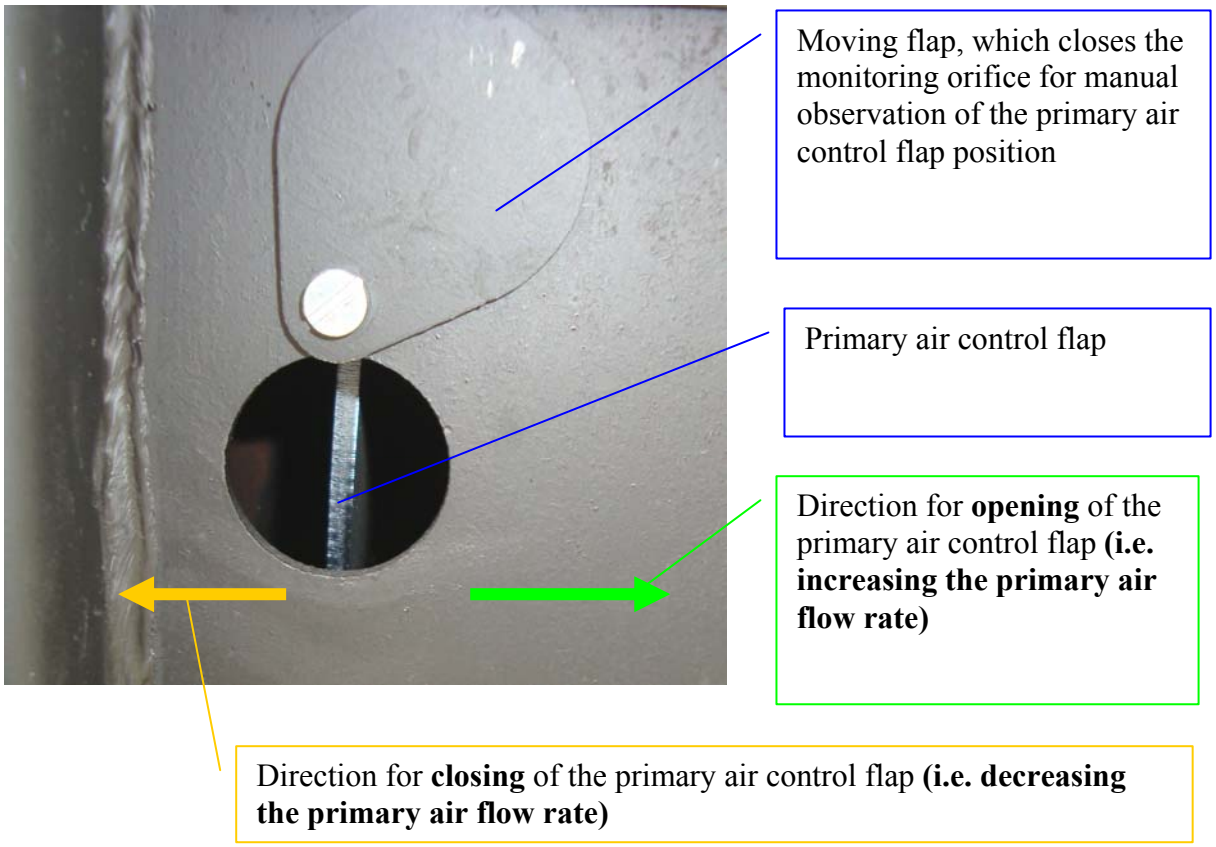

Moving flap, which closes the monitoring orifice for manual observation of the primary air control flap position
Primary air control flap
Direction for **opening** of the primary air control flap **(i.e. increasing the primary air flow rate)**
Direction for **closing** of the primary air control flap **(i.e. decreasing the primary air flow rate)**

Figure 5.9. View of the primary air control flap and the air distribution box;

EXPLANATION : *the moving flap is installed in order to allow visual inspection of the primary air control flap. At nominal operating conditions this flap should close the orifice*;

- **Adjustment of the combustion process**

  The adjustment of the operating parameters, which define the thermal capacity of the hot water boiler, should be performed by authorized, trained and certified technician in order to achieve efficient combustion process and optimal performance of the unit. It is recommended to make the adjustment of the combustion process by measurements with flue gas-analyzer.

  - The **primary air flow rate**, which is adjusted with the position of the primary air control flap, is required in order to sustain the pyrolisis process, organized in the fuel hopper chamber of the boiler. By changing the position of this flap, it is possible to control the volatile gases release rate, i.e. the thermal capacity of the boiler – this is possible in narrow range of the operating mode of the boiler. As a rule of a thumb, at higher moisture content of the fuel, the position of the primary air control flap should be opened (by pulling the axes of the flap out of the boiler) and fixed again with the screw. ATTENTION**:**

small change of the position of the primary air control flap leads to sensible variation of the primary air flow rate and consequently the intensity of the pyrolisis process – it is highly recommended to change the position of the flap with small steps (for example 1mm);

- The **secondary air flow rate** is controlled by changing the position of the primary air control flap –at decreasing the primary air flow rate the secondary air flow rate is increased and vice versa. The air is directed in from the distribution box to the burner's nozzle, where it is preheated and afterwards mixed with the volatile gases at the burner's nozzle;

The total air flow rate, drawn in, is controlled by the position of the flap, which is installed at the air entrance of the air distribution box of the boiler. The position of this flap is controlled with the lever of the thermovalve of the boiler. The adjustment of the air flow rate for achieving efficient combustion process should be done by trained and authorized technician by measuring the operating parameters of the flue gases with gas-analyzer. The practice shows that event if the combustion process of the boiler has been adjusted, after passing some time new settings (i.e. new adjustment) will be required, because a lot of operating parameters could be changed – for example the fuel has been changed, changing the thermal capacity of the boiler and/or heating system, chimney's operating conditions, etc. considering that, the following information will be helpful for not trained person to make appropriate adjustment of the operating parameters of the boiler in order to achieve high efficiency and optimal fuel utilization.

As primary step of the combustion process operating parameters adjustment, it is necessary to perform visual inspection of the flame – this is done by opening the door of the combustion chamber and seeing the shape and the color of the flame, after that the door should be closed.

EXPLANATION: *at opening the door of the combustion chamber, the static pressure in this chamber will be immediately changed, which will influence the combustion process (practically the combustion chamber operates at pressure, which is lower than the atmospheric one), that's why it is necessary to make fast observation of the flame in the combustion chamber, before the ambient air penetration to make influence on the thermal process.*

The flame, getting out of the burner's orifice is directed downwards and should reach the ceramic flue gases directing element, positioned in the combustion chamber of the boiler. The color of the flame at nominal operating conditions and optimal combustion process (i.e. the process is

organized at low CO content in the flue gases as well as low air excess ratio) should be **saturated yellow** and the edges of the flame should be **blue** colored.

In case that the colour of the flame is:

- Saturated red – *this shows that there is deficiency of secondary air – it is required to increase the secondary air flow rate by opening the total air flow rate control flap (driven by the thermovalve)*;
- **Light yellow or with short length** – *this indicates, that there is excess of secondary air and the secondary air flow rate should be decreased by closing the total air control flap – adjust the thermovalve, which controls that flap*;
- The flame has low intensity (so called "lazy flame") – *this shows that the primary air flow rate should be increased – it is necessary to open the primary air control flap by pulling the axes of that flap*;
- Smoke in the flame – *this shows that there is absence of secondary air and increased intensity of volatile gases as well as tar release rate.That's why it is necessary to decrease the primary air flow rate and to increase the secondary air flow rate – in order to do that, one should close the primary air control flap by pushing it. The effect of this adjustment will be seen in a period of at least 15 minutes, so one has to be patient and wait. The change of the axis position should be done in small steps, as this adjustment is highly sensitive*;

The criteria for optimal combustion is the operating conditions of the ceramic element, positioned in the combustion chamber of the boiler – the outer surface of the ash layer should be light-grey by color, the quantity of the deposited ash should be relatively small, no unburned charred particles should be seen (chars are dark colored particles).

The quality of the adjustment of the combustion process could be estimated by monitoring the color of the flue gases, released out of the chimney, which is connected to the boiler. In case that the flue gases are dark colored, that is sign for deficiency of secondary air and/or the fuel quality is not covering the requirements (most often the moisture content is higher than required).

The flue gases, emitted in the atmosphere from the chimney, could eventually change the transparency of the air, thus the flue gases presence could be recognized, even light refraction could be observed at high difference of the temperature of the flue gases and the temperature of the ambient atmosphere. The products of the combustion process (mainly water vapor H_2O and carbon dioxide – CO_2) are not visible. However, at

low temperature of the ambient air (for example -10^{o}C or even lower) the water vapor in the flue gases could condense and light smoke rake will be visible above the exit orifice of the chimney.

EXPLANATION: *the flow rate of the air, drawn in for the combustion process strongly influences the operating conditions of he boiler – its thermal capacity as well as its efficiency – in case the air flow rate is below the optimal one, then the fuel will be partially oxidized, i.e. low combustion efficiency, at high air flow rate the combustion process will be cooled down and again the efficiency will be decreased.*

5.3.8. Estimating the thermal capacity of the boiler

The estimation of the thermal capacity of the boiler in practice could be done by measuring the fuel flow rate, i.e. the consumption rate and to estimate the heating value of the fuel, as well as the efficiency of the boiler. In the following section is described in details:

- ***Measure the average fuel flow*** *for defined (or assumed) period of time (for example one hour) – m_{wood_logs} = 10.7 kg/h. Calculate the instant fuel flow rate, by dividing the averaged mass of the fuel by 3600 (1 hour = 3600 seconds) and get the result m'_{wood_logs} = 0.002972 kg/s;*
- ***Estimate the heating value of the fuel*** *– H_{wood_logs} = 13.9 MJ/kg = 13900 kJ/kg; In case that the moisture content is not known, then it has to be estimated (or assumed)– see figure 2.1 , table 2.1;*
- ***Estimate (or assume) the efficiency of the boiler*** *at nominal operating conditions – η_{boiler}=85%=0.85 (or the efficiency at the estimated thermal capacity of the boiler);*
- ***Calculate the thermal efficiency of the boiler*** - $P_{boiler} = \eta_{boiler} * H_{wood\_logs} * m'_{wood\_logs} = 0.85 * 13900 * 0.002972 = 35.12\ kW;$
- *In case that the thermal capacity of the boiler should be estimated at different than the nominal operating conditions as well as other fuel is utilized (the type or the moisture content could be different) the same approach should be utilized;*

EXPLANATION:

- *At any change of the thermal capacity of the boiler (for example at change of the fuel type and especially its moisture content)it is recommended to make appropriate adjustment of the operating parameters of the boiler – the position of the of the primary air control flap as well as the position of the flap, which controls the total air flow rate drawn in the boiler;*

- *In case that the thermal capacity of the boiler need to be decreased, this could be achieved by increasing the periods between fuel charging and or decreasing the amount of the fuel charged at any process of boiler's wood logs charging. In principal the decreased thermal capacity of the boiler is accompanied with decreased thermal efficiency, but practice shows that this decrease is relatively low (some percents) and does not influence the overall efficiency of the system, but should be considered when calculations of the thermal capacity of the boilers are done;*
- *In case the heat exchanging surfaces of the boiler have been deposited with ash as well as tar particles, the intensity of heat exchange rate will be decreased, which will lead to decreased efficiency of the boiler and the net heat energy, transferred to the heating system;*

5.3.8.1. Decreasing the thermal capacity of the boiler

In practice the thermal capacity of the boiler is achieved by decreasing the amount of the fuel, charged in the fuel hopper of the boiler. The decrease of the thermal capacity could be achieved by increasing the period between two fuel charging with wood logs. In case the boiler should run at lower that nominal thermal capacity, then it is highly recommended to install a heat accumulator tank in the heating system (see the description above) in order to sustain the optimal performance of the boiler as well as high efficiency of the system;

5.3.8.2. Increasing the thermal capacity of the boiler

In practice the increase of the thermal capacity of the boiler could be achieved by increasing the fuel rate, charged in the hopper of the boiler. In case that the boiler should run for a long period in this operating mode, then it is highly recommended to make appropriate air flow adjustments – see the description above. As the heat consumption is increased, it will lead to more frequent fuel charging of the hopper of the boiler.

ATTENTION : *it is strictly **forbidden** to increase the thermal capacity of the boiler above the **nominal one***;

EXPLANATION: *the practice shows, that the decrease or increase of the thermal capacity of the boiler is relatively difficult to control process, especially when high efficiency is required. It is highly recommended to run the boiler at nominal thermal capacity (i.e. nominal operating mode) and the variations of the of the heat energy consumption will be covered by a heat accumulator tank. The practice shows that a heating system,*

equipped with heat accumulator shows optimal thermal efficiency, high reliability and economic exploitation of the system. The heat accumulator tank also allows flexible fuel charging and boiler's operation – see figure 4.5, where a heating system with heat accumulator is installed;

5.4. Operation of the boiler in "stand-by" mode

During the exploitation of the of the heating system, the fuel consumption rate varies in wide range even in a period of 24 hours. The thermal capacity of the boiler is result of the thermo-chemical processes, organized in the fuel hopper chamber and the combustion chamber as well – in case the fuel has been consumed, the thermal capacity of the boiler will be decreased, also after the fuel hopper has been charged, after approximately 30 minutes the wood logs start to release volatile gases (which is highly intensive process) and leads to increased thermal capacity of the boiler. The efficiency of the boiler also varies along the fuel consumption and time. The practice shows that the boiler and the heating system are seldom balanced – in most case the thermal capacity of the boiler will be higher or lower than the heat consumption rate by the heating system. In case the thermal capacity of the boiler is higher than the heat demand, the temperature of the circulating water will be increased and will be reached the set-point of the operating thermostat of the boiler – in such a case the flue gas fan will be switched off and the boiler will go into stand-by mode, the thermal capacity of the boiler will be decreased to higher extent. In stand-by mode the air is naturally driven in the boiler and the char oxidation in the fuel hopper chamber is sustained. The measurements show that in stand-by mode the thermal capacity of the boiler is approximately 10% of the nominal thermal capacity of the unit. In case that the temperature of the circulating water is decreased, the flue gas fan will be switched on and in a period of 3 - 5 minutes the combustion process will be in nominal operating conditions, the boiler's thermal capacity will be increased as well.

EXPLANATION: *in case the wood logs, placed in the fuel hopper have been consumed, then the thermal capacity as well as the temperature of the flue gases of the boiler will be decreased. In such a case the flue cases thermostat will be activated (when the flue gases temperature is below the set-point of the flue gas thermostat) and the boiler will be switched into stand-by mode (i.e. the flue gas fan will be switched off) and thus the char layer in the fuel hopper chamber will be preserved. After the fuel hopper is charged with new quantity, the boiler will go into nominal operation mode.*

The following figures show the variation of the heat consumption rate of the heating system of a typical heating system in a period of 24 hours, considering the ambient temperature.

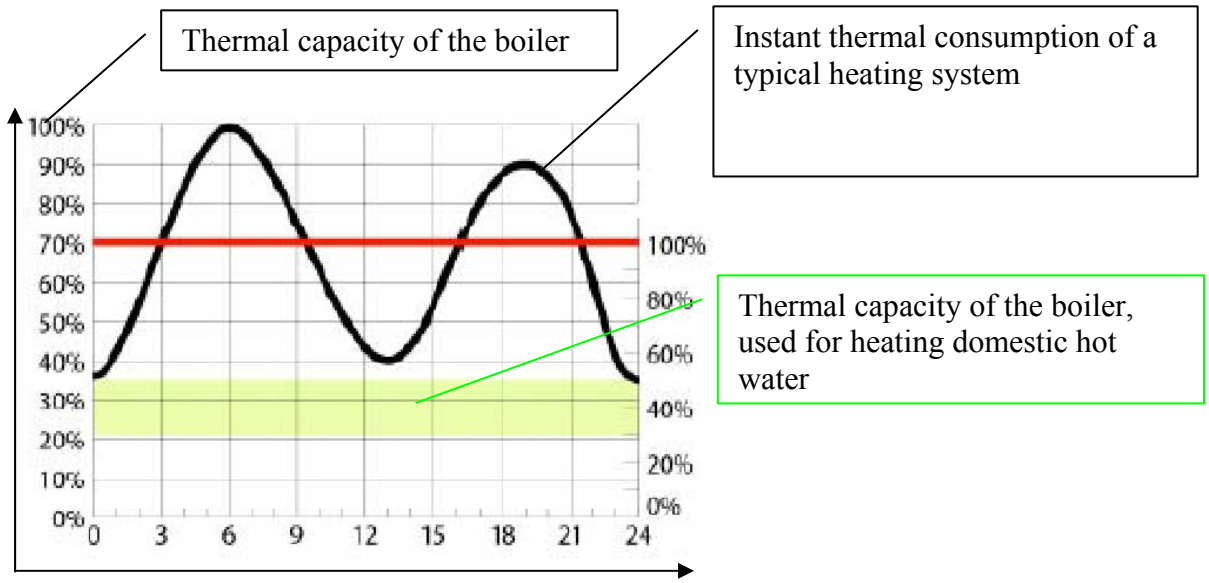


Figure 5.10. Instant thermal capacity of a typical heating system at ambient temperature -15°C;

The figure shows that the thermal consumption rate of a typical heating system varies during the day and typically the highest consumption rate is at the morning. However, the operation of the hot water boiler could not follow the consumption trend in order to cover the heat demand. This is the main argument to install a heat accumulator tank in the heating system.

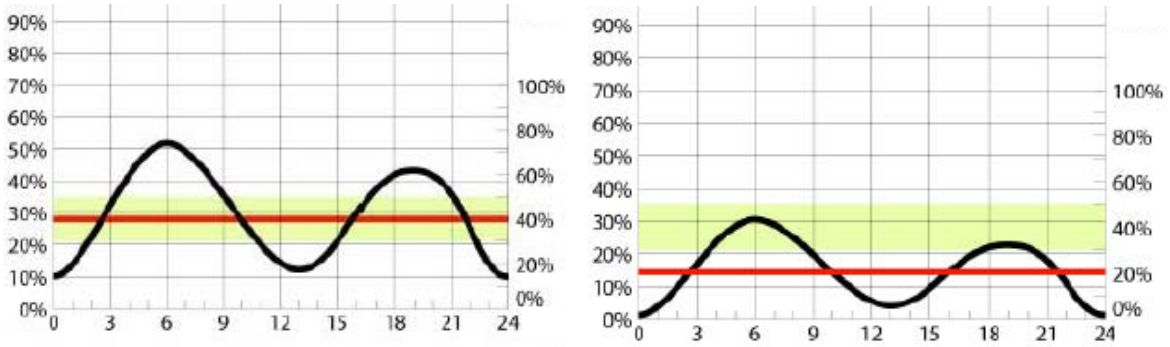


Figure 5.11. Instant thermal capacity of a typical heating system at ambient temperature of 0°C (*the left figure*) and at +15°C (*the right figure*);

5.5. Stopping the operation of the boiler.

Stopping the operation of the boiler should be performed by stopping any flue charging in its fuel hopper chamber. The combustion of the fuel will cease and finally quenched – this process could last for some hour however. Turn OFF the "START" switch, mounted on the interface panel of the boiler. In case that

the boiler will not operate for a relatively short period of time, than it is recommended to clean the ash deposited on the easy accessed heating surfaces of the heat exchanger.

ATTENTION : *In case that the boiler will not operate for a long period of time, then the heat exchanger should be thoroughly cleaned from the deposited ash. The deposited on the metal surfaces ash acts corrosively on the carbon steel surfaces, which will lead to a decrease of the lifetime of the boiler's main modules – heat exchanger, as well as the burner. It is obligatory to perform service procedures and preventive observations of the unit by trained service personal only as well as thorough cleaning at the end of the heating season. Completing these requirements will ensure long exploitation duration of the boiler and its high efficiency and reliability. The service check-up of the boiler as well as thorough ash cleaning allows sustaining the lifetime of the heat exchanger, decreasing the corrosion and eventual damages. This procedure should be performed by authorized and certified technician only.*

5.6. Turning OFF the boiler

The system is turned off by stopping any wood logs charging in the fuel chamber of the boiler and wait the combustion process get quenched, then changing the "START" switch into OFF position. After the boiler has cooled down to ambient temperature, the boiler should be switched off by turning off the main "POWER" switch. It is recommended to clean the deposited ash thoroughly of the heat exchanging surfaces of the boiler.

- **Emergency boiler stop.**

  In operating process of the boiler emergency situations could arise and the boiler will go into alarm/failure mode. Overheating situations are detected by the control board of the boiler and will go into automatic preventive regimes in order to protect the system.The overheating protection thermostat (the alarm thermostat) will be activated and the "ALARM" indicator lamp of the boiler in case of overheating will indicate this state of the boiler. After the cause of the alarm situation is clarified, take adequate actions for bringing back the boiler into normal operating conditions.

  ATTENTION : *in case of emergency situation – boiler overheating, the emergency thermostat is activated. In this case the boiler should be cooled down and the reason for such excessive process should be investigated and preventive measures should be performed. The emergency thermostat should be manually reset by unscrewing its preventive cap and its stem should be pressed until the thermostat switches back on (a "click" sound is*

heard in this process), screw the cap back. After the boiler is checked and the cause for overheating is determined and repaired turn the "POWER" switch ON in order to operate the boiler in normal operation mode. ATTENTION – the check-up procedure of the boiler, as well as the heating systems for finding the cause for overheating should be performed by trained authorized technician. *After has been started-up again ,the entire system, as well as the boiler should be heated up at moderate rate and should be monitored for any untypical situations, in order to prevent any alarm mode to rise*;

ATTENTION : the stopping of the combustion process of the fuel in the hopper chamber should not be done by forced quenching (by pouring water and/or thoer fire extinguishing materials), because this could cause

ВНИМАНИЕ : *спирането на процеса на горене в камерата за гориво не трябва да става чрез принудително гасене (чрез вода или други гасителни течности), тъй като това би могло да доведе до irretrievable damages of the heat exchanger and the burner's nozzle. It is highly recommended to cool down the heat exchanger by natural cooling down to the ambient temperatures and after that to perform thorough investigation of the boiler and the control modules of the system* – **this should be performed by authorized and trained technician as well**;

5.7. Cleaning the ash of the boiler

The cleaning-up of the deposited ash on the heat exchanging surfaces of the boiler should be performed **regularly**, which allows efficient operation and high reliability of the unit.

The cleaning of the ash, deposited on the surfaces of the combustion chamber of the boiler should be performed before any boiler's start-up process (before firing up the fuel) or in case the boiler has not been stopped for couple of days – the ash should be cleaned on a period of 2-3 days, considering the thermal capacity and the fuel consumption rate, as well as the properties (mainly the ash content) of the wood logs.

ATTENTION: *at the ash cleaning process small amount of the mineral matter will be released as fly ash, diluted in the ambient air – it is highly recommended to have individual protecting wear (for example a mask, which will protect the human from breathing the small ash particles)*;

Figure 5.12. Tools (scrapper and a brush) for cleaning the ash from the boiler's heat exchanging surfaces;

EXPLANATION:

- *The regular cleaning of the ash, deposited on the heat exchanging surfaces of the boiler allow achieving high reliability and efficient operation of the boiler, as well as high durability of the heat exchanger;*
- *Another criteria for efficient combustion process and optimal operation of the boiler, is the color of the ash as well as the presence of any char particles in the ash material – the amount of these particles should be small, compared to the total ash mass;*
- *The cleaning of the ash in the combustion chamber could be performed at operation mode of the boiler, but should be done in exceptional cases – the boiler should be cooled down (but still operating) and special measures for self protection should be taken in order to prevent any skin injuries. It should be considered, that hot flue gases will be emitted in the boiler's room and thus suffocation could influence the person, who is making the above mentioned process – take care to make intensive ventilation of the boiler's room. In case that such ash cleaning is a must-process, then the ignition flap should be opened, the door of the combustion chamber should opened and the ash should be scrapped and collected in a special container, which is equipped with appropriate lid – take care not to get burned by the hot particles. After the ash has been cleaned, close the door of the combustion chamber, then close the ignition flap. Take the ash container away and leave it to get cooled down to ambient temperature levels, then empty the ash in appropriate containers or use it as fertilizer for example;*

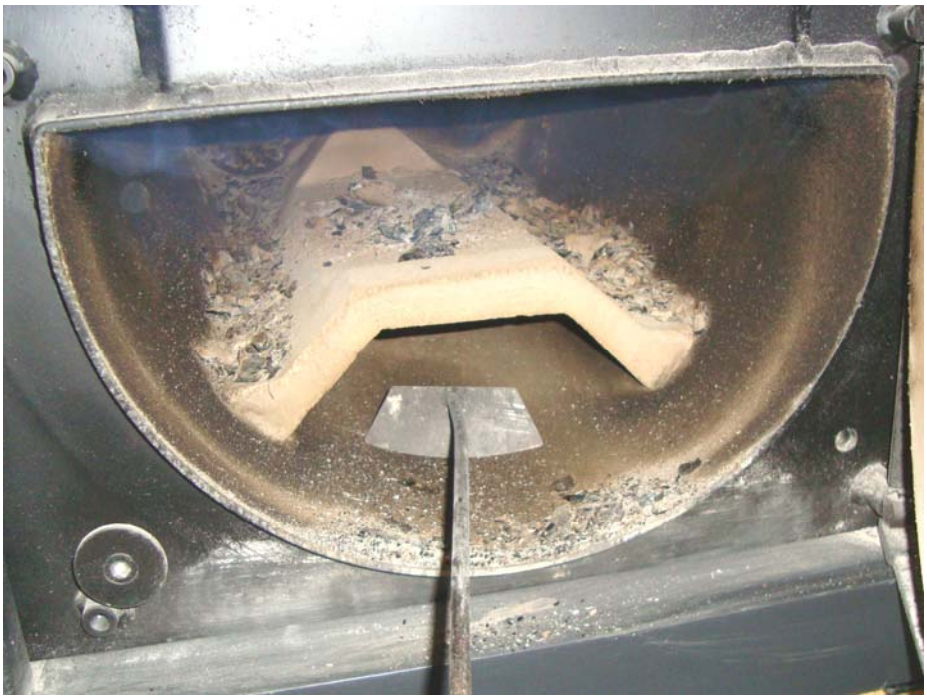


Figure 5.13. Cleaning the ash residue, deposited in the combustion chamber – use the scrapper to clean the ash layer as well as the char particles;

RECOMMENDATION – *in order to minimize the risk, it is recommended to place a metal shovel or an appropriate container, where the ash will be collected, taking care not to spill the material away. The collected ash and char residues should be kept in a lid closed container (or any appropriate vessel) and to be cooled down to ambient temperature level – please consider the safety first*;

The cleaning procedure of the convective heat exchanger of the boiler should be performed at least once per month, but in practice the operating mode and mainly the total amount of the fuel consumed should be considered. The practice show that about 30 to 40% of the ash content of the fuel is transported by the flue gases to the convective heat exchanger section of the boiler, which leads to sensible decrease of the heat transfer rate of the flue gases to the circulating media, i.e. the total efficiency of the boiler will be decreased. However, the fly ash particles will be transported by the flue gases from the boiler out to the chimney, so the chimney also collects considerable amount of ash, which should be cleaned as well. The turbine of the flue gas fan will be deposited with fly ash and char particles as well. Please note, that the fly ash accumulates in elbows and other elements of the chimney, as well as the convective duct section of the boiler will result to increased hydraulic loses of the convecting flue gases, eventually the duct could be stacked and blocked, which will result in sensible decrease of the draught of the chimney and even the boiler could emit flue gases out of the door gaskets as well as other lids. ***It is highly recommended to clean***

the deposited ash in the convective section of the boiler, as well as the chimney regularly.

Cleaning the convective duct of the boiler is performed in the following way:

Unscrew the specialized fixing nuts, which are used to tighten the lid of the convective duct of the boiler and carefully detach the covering lid. Practice shows that in some cases the gasket could be adhered to the plates of the convective section, which will to difficult detachment of the lids – take care no to damage the gasket rope, eventually it has to be replaced.

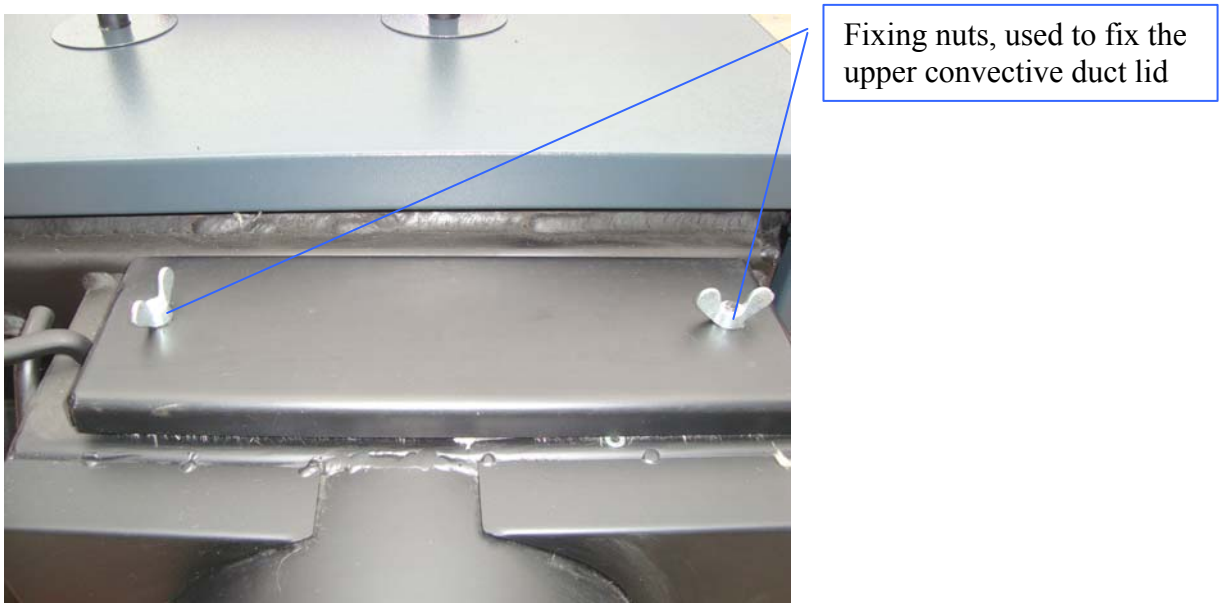


Figure 5.14. Convective lid, which covers the upper orifice for cleaning the deposited ash on the heat exchanging surfaces of the boiler;

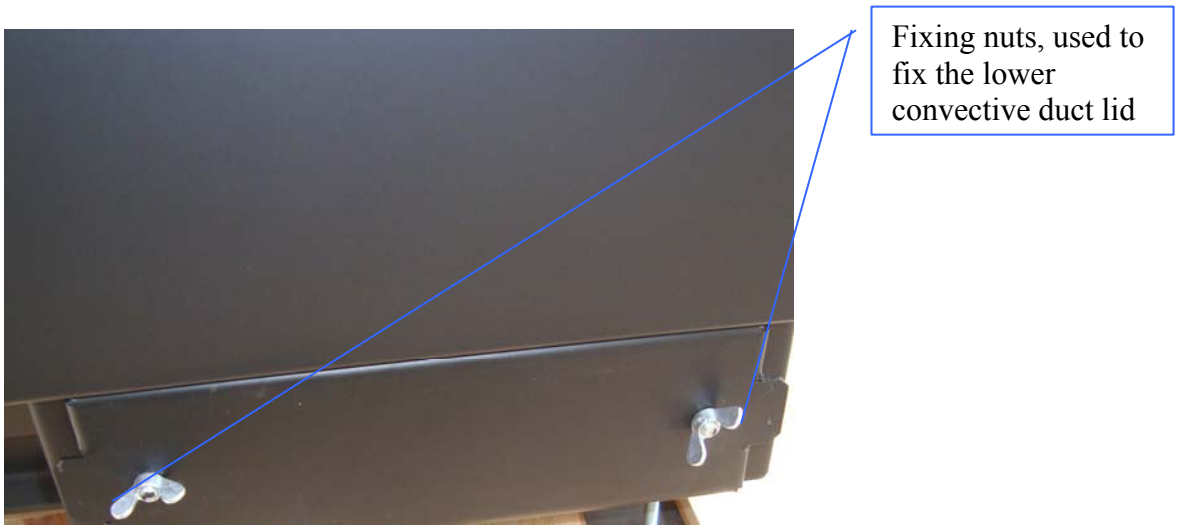


Figure 5.15. Convective lid, which covers the lower orifice for cleaning out the ash, collected after the cleaning process on the heat exchanging surfaces of the boiler;

After the fixing nuts have been unscrewed and the upper lid has been detached, the installed turbulizers, which are positioned in the convective section of the boiler.

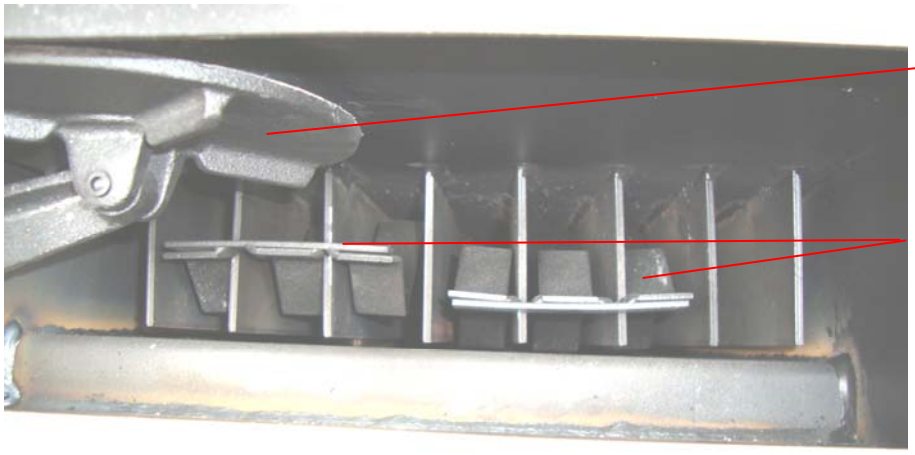


Figure 5.16. Turbulizers, installed in the convective section of the boile**r**;

The cleaning procedure of the ash should be performed with a specialized tool – a metal brush, by pushing and pulling the brush upwards and downwards. After the ash has been brushed away, the collected ash residue should be cleaned by opening the lower lid and to scrape out the ash out of the lower section of the convective heat exchanger of the boiler.

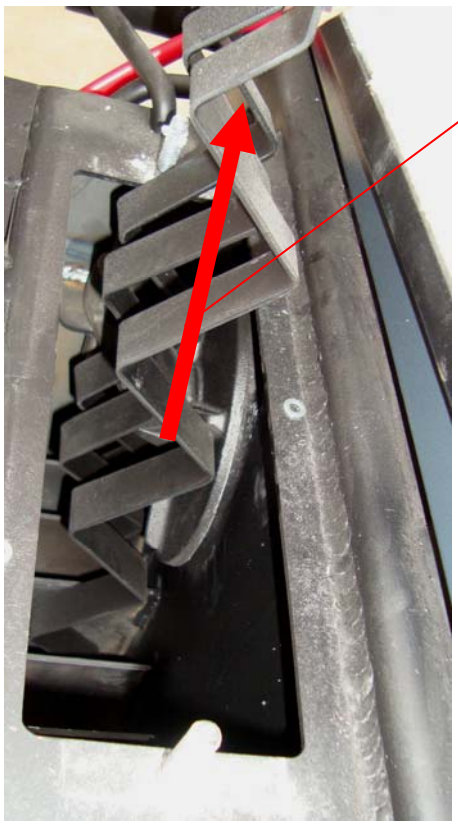

Draw out the turbulizers (upwards). The practice shows that these elements could be stuck due to ash deposition – it is necessary to make careful handling and vertical lifting of these elements

Figure 5.17. Lifting the turbulizers out of the convective heat exchanger duct of the boiler;

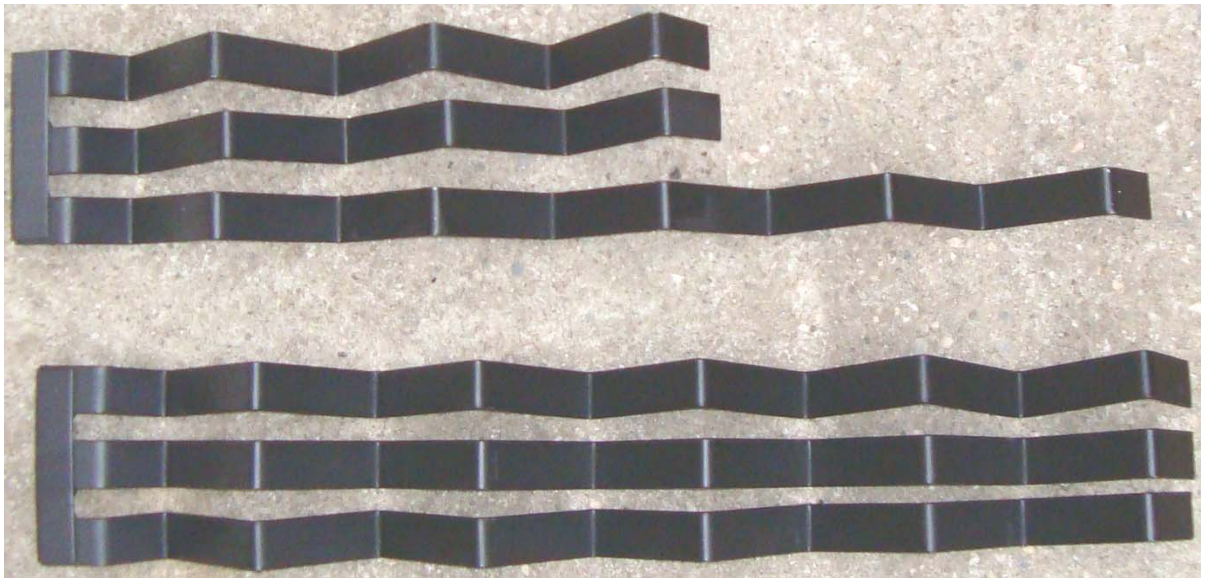


Figure 5.18. View of the turbulizers, detached out of the boiler;

EXPLANATION: *the turbulizers of the boiler differs one from another and attention should be paid in order to remember which one where should be positioned – one of these elements has shorter curved elements, practically the place of the elements could not be mistaken due to special feature of the design of the boiler*;

The ash cleaning of the convective duct of the boiler should be performed as shown on the following figure.

Figure 5.19. Brushing the ash, deposited on the heat exchanger of the convective duct of the boiler;

After the convective duct of the boiler has been cleaned out from the deposited ash, it is recommended to clean (or at least check the condition) the turbine of the flue gas fan of the boiler – this procedure should be carefully done. ATTENTION – clean the deposited ash as well as other tar residues of the turbine of the flue gases fan by using a soft brush (do not use any wire brush or any other stiff cleaning tool), by operating through the inlet of the flue gases fan orifice.

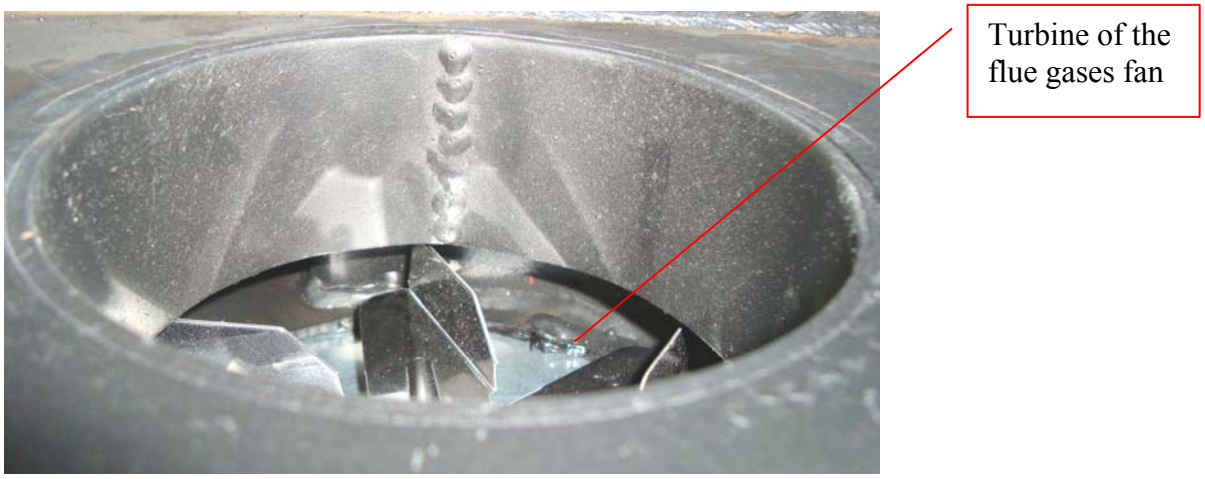


Figure 5.20. View of the inlet orifice of the flue gases fan;

EXPLANATION : *it is highly recommended to detach the flue gas fan and to clean it thoroughly, next it should be carefully installed back on the boiler, considering the gasket and the its tightness. The flue gas ash cleaning procedure should be performed at switched off electrical power supply of the boiler, as well as unplugged power supply cable of the boiler –* ***this requirement is obligatory***;

After the ash residue of the heat exchanging surfaces has been brushed and cleaned, the lid of the lower orifice of the convective duct should be opened - the ash particles are collected in the volume of this section of the boiler – see the following figure.

Figure 5.21. View of the orifice for ash removal from the lower section of the convective section of the boiler;

After the ash cleaning procedure has been finished, the elements (turbulizers, flue duct lids) are installed and tightened in a reverse manner;

5.8. Showing and teaching the end user about the maintenance and adjustment procedures of the boiler

It is necessary to show and teach the end user the maintenance procedures for operating the boiler efficiently and keep its reliability in high degree order. Also the installer should demonstrate and teach the end user how to change the operative parameters of the control board of the boiler in order to operate the unit, according to the local heat consumption:

The end user should be introduced with the following:

- this instruction manual;
- the operation of the boiler;
- the method for adjustment of the thermal capacity and the operation mode control of the boiler;
- the procedure for boiler's maintenance:
- the procedure for ash cleaning from the combustion chamber of the boiler;
- the procedure for cleaning the ash residue of the convective duct of the boiler;

- **the procedure for charging the fuel hopper with wood logs** – the logs are arranged in the fuel hopper in the chamber, in order to allow easy flow rate of volatile flue gases to the burner's nozzle of the boiler. It is strongly required to utilize chopped wood logs, which have moisture content, according to the requirements for the fuel.;
- **ignition procedure –** *the ignition process is described in details in 5.3.3;*
- **procedure for ash cleaning** – the end user should clean the deposited ash on the combustion chamber surfaces, as well as the ash, deposited on the other surfaces of the boiler. The detailed description is shown in 5.7;
- **cleaning the ash as well as other residues from the turbine of the flue gases fan** – it is highly recommended to perform regular ash cleaning. It is required to stop the boiler and clean the turbine in case

that non typical noise is heard from the fan. Clean of the deposited ash, tars and other depositions from the turbine of the boiler;

ATTENTION : *regular cleaning of the ash residue, deposited on the heat exchanging surfaces of the boiler will ensure long-life reliable exploitation period, economic and efficient performance of the unit;*

5.9. Safety and unexpected risks

Risks could arise at the exploitation of the boiler:

The wood gasification hot water boiler of series "Pyrotherm" is designed according to the safety requirements of the operating European standards and norms. However safety and unexpected risks could arise in situations like following:

- *Hot water boiler of series "Pyrotherm" is operating incorrectly;*
- *The boiler is installed by unauthorized/unqualified personal;*
- *The safety instructions, described in this manual are not followed and fulfilled;*

Unexpected risks:

The boiler is designed and produced according to the requirements of the operating EU safety norms. However, in spite of that possible risks are considered as a result of the operating process of the boiler, it is possible to arise risks as follows:

- ***Cauterization risks**, caused by high temperatures, as a result of the combustion process in the combustion chamber and/or direct access to the front door of the combustion chamber, at manual cleaning processes of the surfaces and combustion chamber, or ash residue cleaning, accumulated in the combustion chamber or any unburned fuel material or smoldering one;*
- ***Electrical shock risks** at indirect contact. The boiler is connected to the power circuit and its operating elements are separated in specialized electric control box, equipped with required protective and short-circuit preventive fuse. It is obligatory to perform system ground connection by authorized personal/technician;*
- ***Fingers injuring risks** at opening/closing the doors/lids of the boiler at maintenance and cleaning process of the unit. It is recommended to use appropriate individual resources for self-protection;*
- ***Suffocation risks** due to flue gas uncontrolled emissions in the boiler's room, in case when the chimney draught is insufficient, in case that the*

convective part of the boiler is clogged, or in case that the flue gas duct is not fully tightened and gas leaks are possible – it is highly recommended to use personal protective breathing mask;

5.10. Operation faults and their repairing

No	Operation fault	Cause	Method for repairing
1.	Low temperatures in the heat supplied rooms	Insufficient heat capacity of the boiler	It is necessary to increase the frequency of fuel charging and/or increase the amount of fuel, charged
			It is necessary to make adjustment of the thermal capacity of the boiler – see 5.3.7
			Check the moisture content of the wood log, eventually replace the fuel with drier one
		Low set-point temperature of the boiler's operating thermostat	It is necessary to increase the set-point of the boiler's operating thermostat (up to 90^{o}C)
		Low set-point temperature of the remote room thermostat (if connected)	It is necessary to increase the set-point of the room thermostat
2.	High temperatures in the heat supplied rooms	High set-point temperature of the boiler's operating thermostat	It is necessary to decrease the set-point of the boiler's operating thermostat (it is recommended to keep it above 65^{o}C)
		High set-point temperature of the remote room thermostat (if connected)	It is necessary to decrease the set-point of the room thermostat
		High thermal capacity of the boiler	It is necessary to decrease the frequency of fuel charging and/or decrease the amount of fuel, charged

3.	Boiler's emergency overheating	Absence of heat consumption or incorrect adjustment of the operating parameters of the boiler or poor operation of the heating system	It is necessary to check the correct operation process of the heating installation and eventually appropriate adjustment of the operating parameters of the boiler and/or control valves of the heating system – *this should be performed by authorized technician*. After the boiler is cooled down to ambient temperature and the reason for boiler overheating is serviced/solved out, the protective cap of the emergency overheating thermostat should be unscrewed, its rod should be pressed until the thermostat is reset and it's cap should be screwed back. The main "POWER" switch is turned OFF and back ON afterwards and the boiler should be started.
4.	The flame looks "opaque" and smoke is observed at the exit of the chimney	Low quality wood logs (in most cases the moisture content is higher than 20%)	Fuel replacement is recommended, use wood logs, which have properties, covering the requirements
		Inappropriate operating parameters adjustment	It is necessary to perform adjustment of the operating parameters of the boiler and achieve efficient combustion process – *see 5.3.7*.
5.	Presence of unburned fuel in the combustion chamber	Ineffective fuel combustion process	It is necessary to perform adjustment of the air flow rate – *see 5.3.7*
6.	High temperature of the flue gases (if flue gas thermometer is mounted)	The heat exchanging surfaces of the boiler are deposited with ash, presenting heat resistive layer, thus	It is necessary to clean thoroughly the heat exchanger surfaces of the boiler;

		decreasing the heat exchanging intensity	
7.	Water vapor condensates on the surfaces of the heat exchanging surfaces of the boiler	Low temperature of the inlet water flow	It is necessary to perform adjustment of set-point temperature, which controls the circulating pump of the heating system. It is recommended to adjust the thermostat set-point to minimum of 65^{o}C;
8.	Flue gases are emitted out in the boiler's room after certain period of exploitation	Insufficient chimney's draught	It is necessary to check and eventually clean the chimney. It may be required to heat-up the chimney in order to allow efficient operation of the chimney
			It is necessary to check the parameters of the chimney and to check if any changes are required (the height , the cross-section, insulation, etc *– performed by expert;*
		Ash deposited or clogged chimney	It is necessary to clean the ash, deposited in the chimney
		Ash deposited of clogged convective duct of the boiler	It is necessary to clean the convective duct of the boiler *– see 5.7*
		Ineffective performance of the gasket of the doors and/or lids	It is necessary to replace the gaskets of the doors – *performed by technician*
9.	Other failures, not described above		It is necessary to consult authorized technician and eventually service maintenance should be performed

Table 5.1. Description of operation faults of wood gasification hot water boiler "Pyrotherm", causes and methods for repairing.

5.11. Hot water boiler warranty form completion.

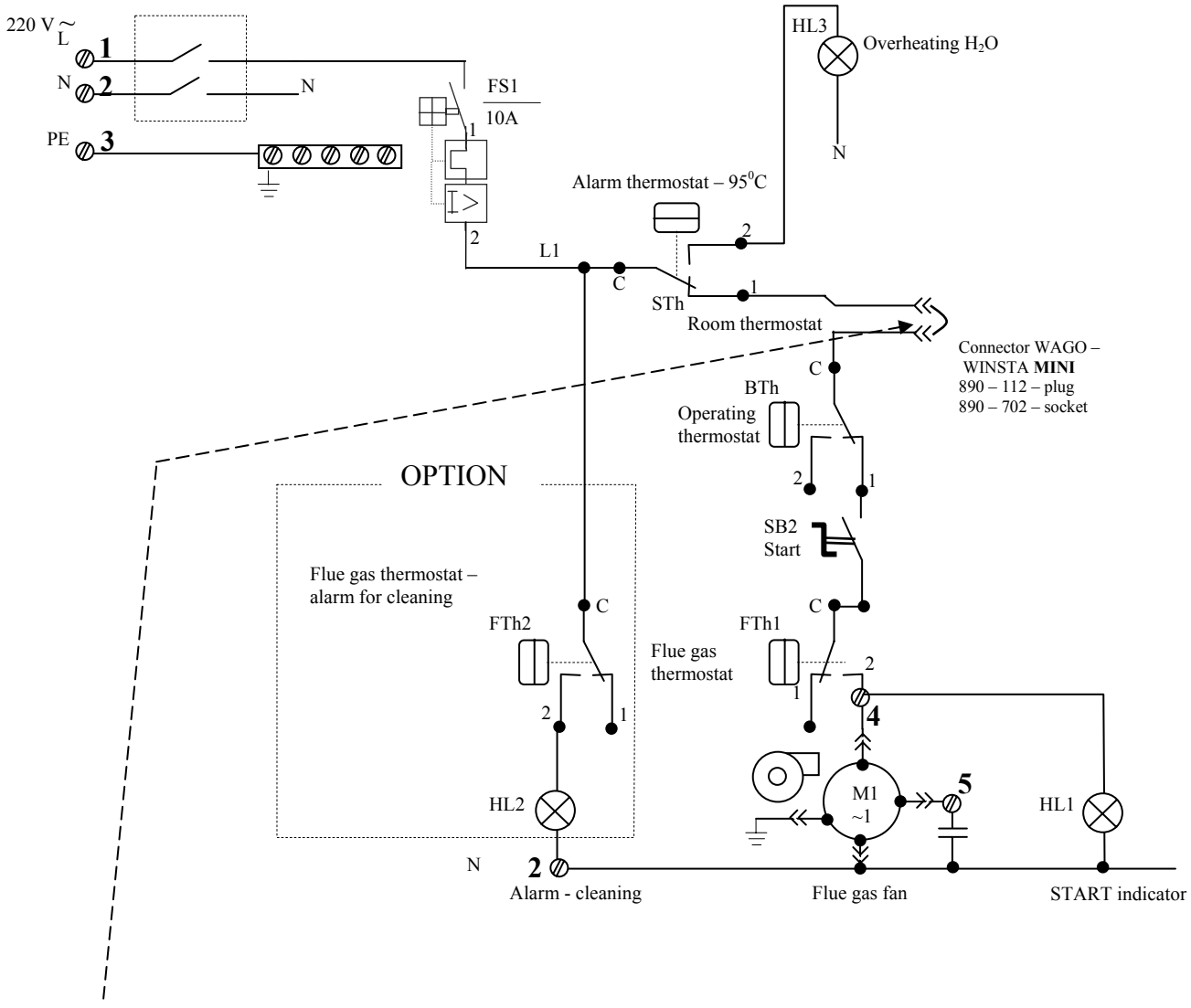
The applied WARRANTY FORM should be completed, by filling the required information in the appropriate fields. The assigned field for signatures and stamp should be completed as well in order to VALIDATE the WARRANY FORM of the unit.

5.12. Actions, after the unit is not in exploitation anymore.

After the lifetime period of the unit has been completed, then it should be treated properly in order to preserve environment contamination. The unit should be dismounted and disassembled by environmentally safe methods. This requirement is most commonly completed by appropriate components recycling, considering separate waste disposal and utilization methods.

6. Electrical scheme of control board of wood gasification hot water boiler of series “Pyrotherm”.

Figure 6.1 shows the electrical scheme of hot water wood gasification boiler of series “Pyrotherm”.



ATTENTION: *the room thermostat connector should be plugged in. It has factory set electrical bridge. Remove the bridge and connect the room thermostat to this connector.*

Figure 6.1. Electrical scheme of the boiler’ control board of series „Pyrotherm”;

Instruction for cleaning pyrolitic boiler

Pyrolica

Before cleaning the utility must be turned off and cooled down!

It is obligatory to use safety guards!

Erato Appeals! Read the user manual guides!

Open upper door and clean inside walls with the scrapper.

Open lower door and clean the ash remains in fireproof dish, starting from top...

... continue downwards.

Open top lid at boiler's back side.

Remove flue gas turbolators.

Clean with brush-rod. Install the turbolators back. Install the cover back.

Open lower cover at the back side of the boiler.

Remove the ash remains.

Install the cover back.

Cleaning tool set.

Both chambers - Wood log tank and combustion - have to be cleaned before every start.

Flue gas way-passages have to be cleaned once per month.